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16. Abstract

This report presents data and technical analyses for Texas Department of Transportation Project 0-5235. This project focused on the evaluation of traffic sign sheeting performance in terms of meeting the nighttime driver needs. The goal was to develop a nighttime driver needs specification for traffic signs. Full information on the project is presented in Report 0-5235-1 Volume 1.

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DEVELOPMENT OF A MODEL PERFORMANCE-BASED SIGN SHEETING SPECIFICATION BASED ON THE EVALUATION OF NIGHTTIME TRAFFIC SIGNS USING LEGIBILITY AND EYE-TRACKER DATA: DATA AND ANALYSES

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and the
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DISCLAIMER

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CHAPTER 1: PHASE I

This chapter includes details from the Phase I effort, which was designed to validate the test equipment and experimental study. Figures 1 through 3 show the course at the Texas A&M University Riverside campus and along a nearby local road maintained by the Brazos County. Figures 4 and 5 show the luminance measurements of the signs used in Phase I.

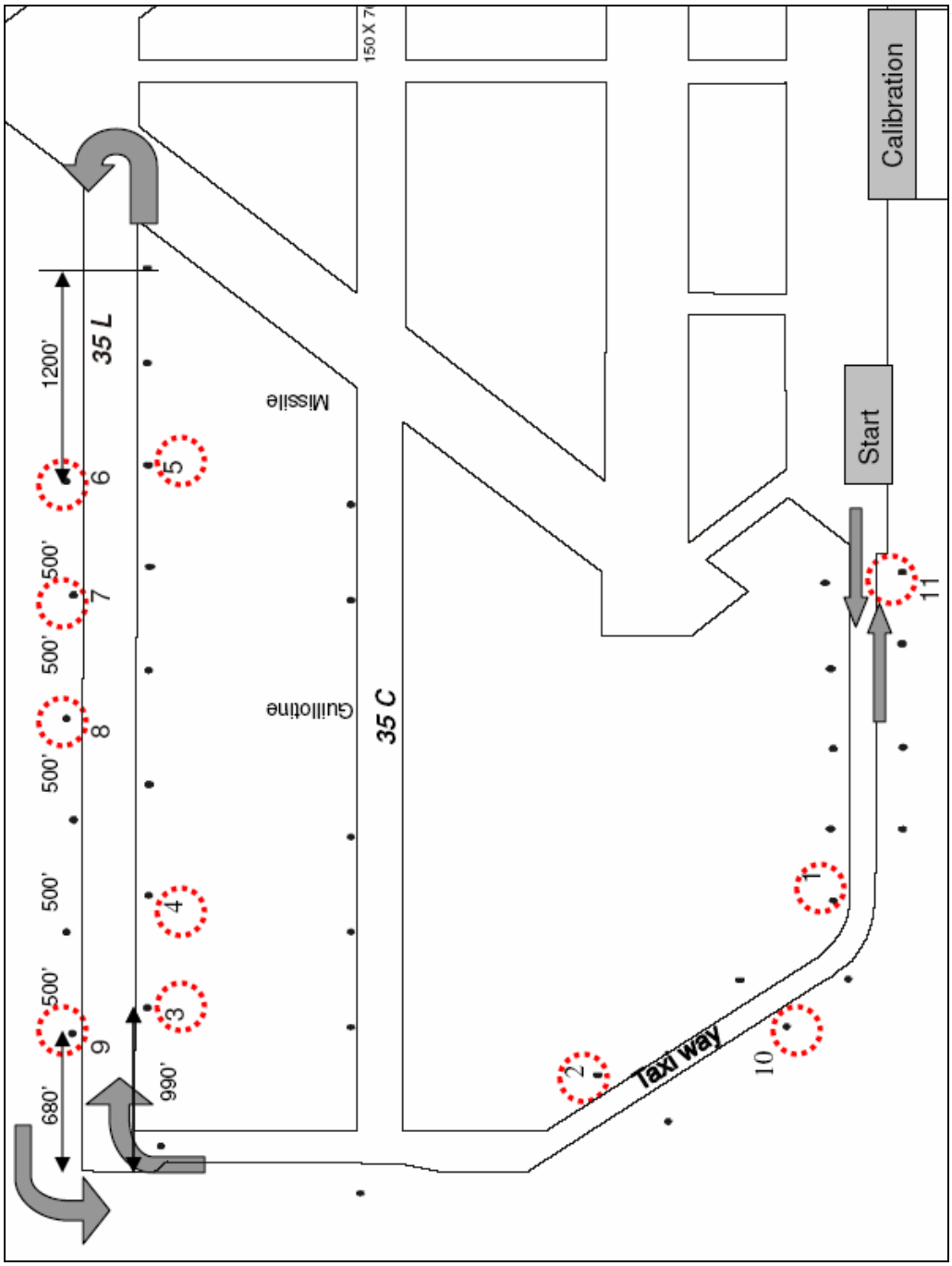


Figure 1. Phase I – Runway Course.

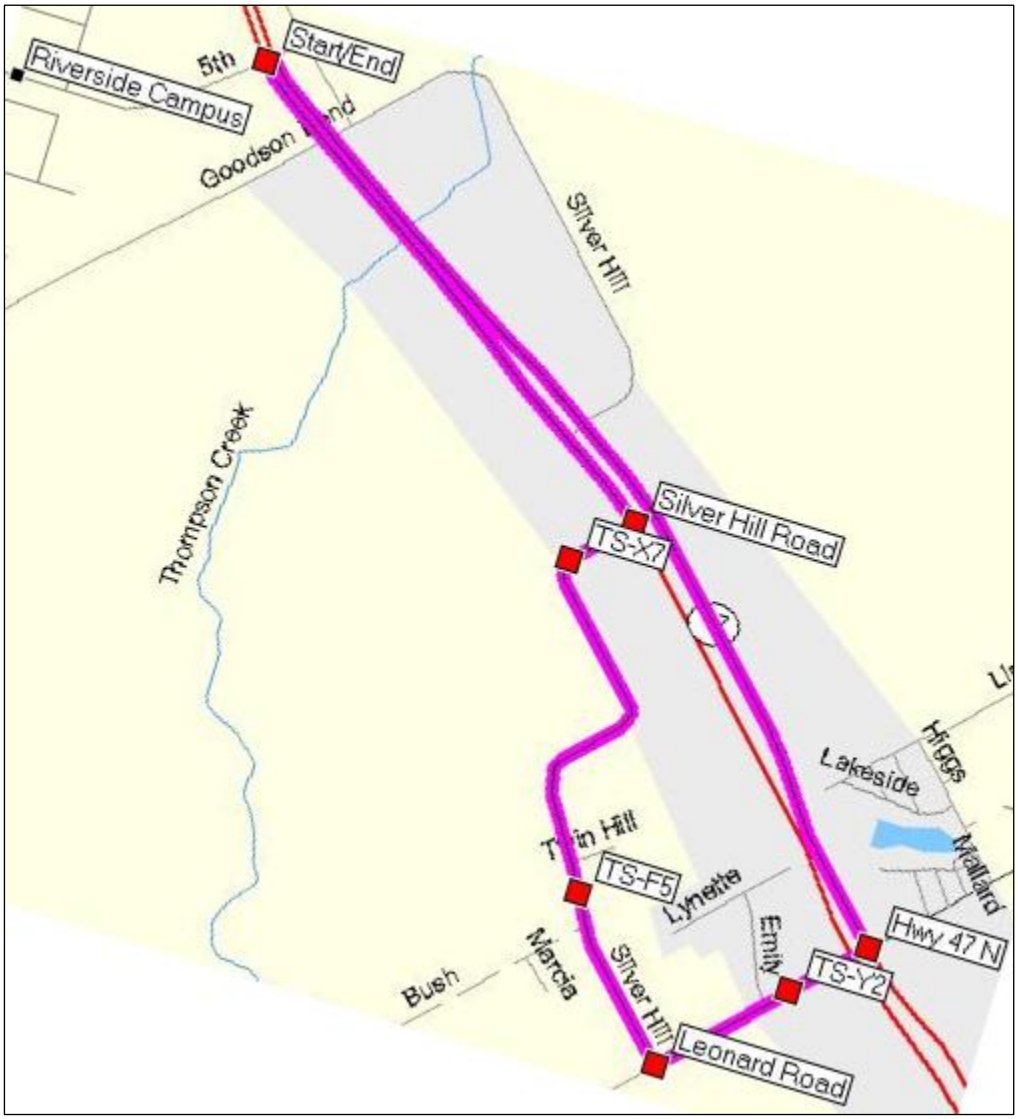


Figure 2. Phase I – Silver Hill Course.

Figure 3. Phase I – 5th Street Map.

Sign 1

Distance (ft)	Luminance (cd/m2)
200	9.3
250	17.9
300	32.3
350	26.3
400	31.6
500	59.9
600	150.6

Sign 2

Distance (ft)	Luminance (cd/m2)
80	1.1
120	2.8
160	6.4
260	40.9
360	84.6

(white)

Sign 3

Distance (ft)	Luminance (cd/m2)
100	1.2
150	2.9
200	7.0
300	41.8
400	112.0

Sign 4

Distance (ft)	Luminance (cd/m2)
100	0.4
150	1.2
200	3.5
300	24.8
400	41.5

Sign 6

Distance (ft)	Luminance (cd/m2)
100	1.5
150	3.5
200	10.7
300	72.4
400	85.2

Sign 7

Distance (ft)	Luminance (cd/m2)
100	1.0
150	3.9
200	9.2
300	56.7
400	156.0

Figure 4. Measured Luminance of Phase I Signs (1 of 2).

Sign 9

Distance (ft)	Luminance (cd/m2)
200	3.5
250	9.6
300	9.8
350	18.5
400	54.6
500	79.7
600	77.5

Sign 10

Distance (ft)	Luminance (cd/m2)
80	1.1
120	2.7
160	2.9
260	9.2
360	12.9

(white)

Sign 11

Distance (ft)	Luminance (cd/m2)
200	25.7
250	30.5
300	39.4
350	54.8
400	70.5
500	139.1
600	106.4

Sign 12

Distance (ft)	Luminance (cd/m2)
200	7.4
250	18.6
300	12.5
350	
400	25.3
500	13.1
600	9.3

Figure 5. Measured Luminance of Phase I Signs (2 of 2).

CHAPTER 2: STATISTICAL RESULTS FROM PHASE II

INTRODUCTION

In this chapter, detailed statistical testing results are presented. These results are from an exploratory effort to examine the legibility data from Phase II and test various techniques to quantify the distance-luminance profiles from the internally illuminated signs. The aim was to better understand how different levels of luminance and different shapes of distance-luminance profiles effect nighttime legibility distance.

In this chapter, Sign 1 is the warning sign, Sign 2 is the guide sign, Sign 3 is the regulatory sign with the 14-inch legend, and Sign 4 is the regulatory sign with the 7-inch legend.

SEPARATE ANALYSIS BY SIGN

In the analyses, the model with Age Group, Acuity Group, Legend, and Aspect of Profile as main effects and Age Group*Legend, Legend*Aspect of Profile, Age Group*Aspect of Profile, and Acuity Group*Aspect of Profile as two-way interactions are used for all of four signs as an initial model. Although the larger models with additional two-way interaction terms were also explored, those additional interaction terms turned out to be insignificant and they are not considered here.

ANALYSIS FOR SIGN 1

Analysis with CLum_CTime 40LI

Table 1 presents the results under the initial model with CLum_CTime 40LI in place of Aspect of Profile for Sign 1. The profiles were defined as follows:

Variables	Description
CLum_CTime 40LI	Total amount of light available to the study subject as they approach the sign from the 40 to the 20LI region
Log 40LI	Log transform of CLum_CTime 40LI
CLum_CTime 50LI	Total amount of light available to the study subject as they approach the sign from the 50 to the 20LI region
Log 50LI	Log transform of CLum_CTime 50LI
CLum_CTime 80LI	Total amount of light available to the study subject as they approach the sign from the 80 to the 20LI region
Log 80LI	Log transform of CLum_CTime 80LI

Table 1. Output for the Initial Model with CLum_CTime 40LI for Sign 1.

Response leg_dist sign=1
Summary of Fit

RSquare	0.720435
RSquare Adj	0.693055
Root Mean Square Error	57.01014
Mean of Response	226.4759
Observations (or Sum Wgts)	427

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	33.17	0.2529	0.6183
Acuity Grp	1	1	33.35	3.5851	0.0670
legend	11	11	355.3	0.7982	0.6420
CLum_CTime 40LI	1	1	355.2	46.5362	<.0001
Age Grp*legend	11	11	355.3	1.0404	0.4099
Age Grp*CLum_CTime 40LI	1	1	355.5	4.2006	0.0411
legend*CLum_CTime 40LI	11	11	358.7	1.1196	0.3445
Acuity Grp*CLum_CTime 40LI	1	1	355.8	1.4117	0.2356

The effect of CLum_CTime 40LI on the legibility distance is positive, i.e., as CLum_CTime 40LI increases, the legibility distance increases, although the coefficient is not shown in the table. Also, there is a significant interaction effect Age Grp*CLum_CTime 40LI on the legibility distance, suggesting that the rate of increase (slope for CLum_CTime 40LI) of legibility distance as CLum_CTime 40LI increases is different for Old and Young Drivers. The residual plot was examined to ensure that underlying model assumptions are satisfied. Figure 6 contains the residual plot, showing seven outliers (represented by squares).

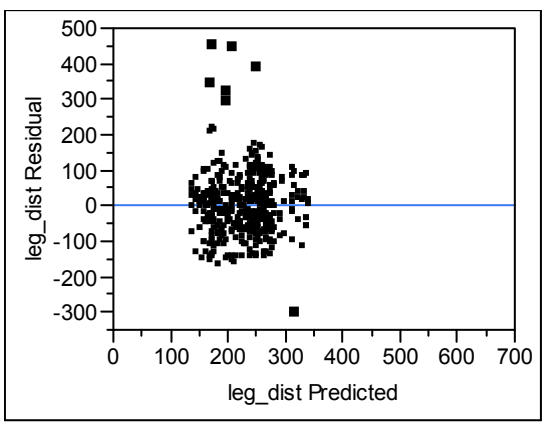


Figure 6. Residual by Predicted Plot for the Initial Model with CLum_CTime 40LI for Sign 1.

The model was refitted after removing those outliers. Table 2 contains the results.

Table 2. Output for the Initial Model with CLum_CTime 40LI for Sign 1 after Removing Outliers.

Response leg_dist sign=1

Summary of Fit

RSquare	0.740821
RSquare Adj	0.715717
Root Mean Square Error	49.80119
Mean of Response	222.0986
Observations (or Sum Wgts)	420

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	32.83	1.0456	0.3140
Acuity Grp	1	1	32.91	6.0142	0.0197
legend	11	11	349.2	0.7611	0.6790
CLum_CTime 40LI	1	1	349.1	62.6260	<.0001
Age Grp*legend	11	11	349.2	0.4815	0.9145
Age Grp*CLum_CTime 40LI	1	1	349.4	8.1669	0.0045
legend*CLum_CTime 40LI	11	11	353	1.7821	0.0556

The residual plot contained in Figure 7 shows that the model assumptions are now satisfied.

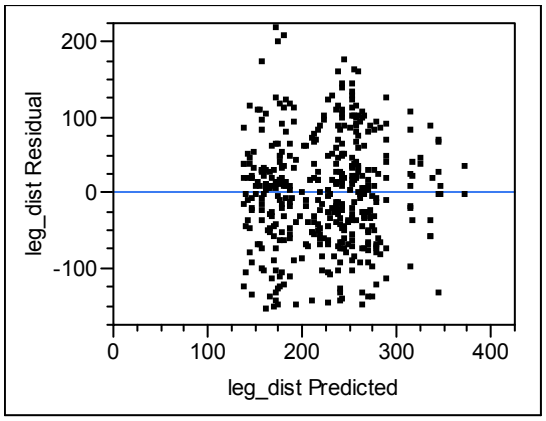


Figure 7. Residual by Predicted Plot for the Initial Model with CLum_CTime 40LI for Sign 1 after Removing Outliers.

An effort has been made to select a more parsimonious model while maintaining good overall model fit. Table 3 contains the model with statistically significant (at α=0.05) effects as well as the main effect variables that are part of significant two-way interaction effects. Table 3 suggests that the overall model fit stays almost the same (especially in terms of the adjusted

R-square) as the initial model(s). The model in Table 3 can be selected as a final model for Sign 1 with CLum_CTime 40LI.

Table 3. Output for the Final Model with CLum_CTime 40LI for Sign 1 without Outliers.

Response leg_dist sign=1

Summary of Fit

RSquare	0.715672
RSquare Adj	0.712932
Root Mean Square Error	49.87858
Mean of Response	222.0986
Observations (or Sum Wgts)	420

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	193.98417	11.06581	36.61	17.53	<.0001
Age Grp[0]	15.277267	14.35129	32.77	1.06	0.2949
Acuity Grp[0]	31.209211	13.60955	32.73	2.29	0.0284
CLum_CTime 40LI	0.2510549	0.031077	381.8	8.08	<.0001
Age Grp[0]*(CLum_CTime 40LI-82.1944)	0.0942351	0.031077	381.8	3.03	0.0026

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	32.77	1.1332	0.2949
Acuity Grp	1	1	32.73	5.2587	0.0284
CLum_CTime 40LI	1	1	381.8	65.2623	<.0001
Age Grp*CLum_CTime 40LI	1	1	381.8	9.1950	0.0026

Table 3 also shows the estimated model coefficients in the Parameter Estimates table. A prediction equation for Legibility distance (Y) for Sign 1 can be written using those coefficients (if desired) as follows:

$$Y=193.98417+15.277267\ \text{Age Grp[0]} + 31.209211\ \text{Acuity Grp[0]} +0.2510549\ \text{CLum_CTime 40LI}$$
$$+0.0942351\ \text{Age Grp[0]*(CLum_CTime 40LI-82.1944)} \qquad (1)$$

where Age Grp[0] and Acuity Grp[0] are indicator functions, i.e.,

Age Grp[0] = 1 when Age Group = 0

= 0 otherwise.

Acuity Grp[0] = 1 when Acuity Group = 0

= 0 otherwise.

For example, when Age Group = 0 and Acuity Group = 0, Equation (1) can be rewritten as:

$$Y=193.98417+15.277267 + 31.209211 +0.2510549\ \text{CLum_CTime 40LI}$$

$$+0.0942351\ (\text{CLum_CTime 40LI}-82.1944)$$

$$= 232.7251 + 0.3453\ \text{CLum_CTime 40LI} \qquad (2)$$

and when Age Group = 1 and Acuity Group = 1, Equation (1) can be rewritten as:

$$Y = 193.98417 + 0.2510549\ \text{CLum_CTime 40LI} \qquad (3)$$

From Equations (2) and (3), it can be seen that the rate of increase (slope for CLum_CTime 40LI) of legibility distance (as CLum_CTime 40LI increases) is larger for young drivers than for old drivers.

Analysis with Log 40LI

Table 4 presents the results under the initial model with Log 40LI in place of Aspect of Profile for Sign 1. Because the same outliers as in the case of CLum_CTime 40LI were observed again, they were removed and the model was fitted to the remaining data.

Table 4. Output for the Initial Model with Log 40LI for Sign 1 without Seven Outliers.

Response leg_dist sign=1

Summary of Fit

RSquare	0.763074
RSquare Adj	0.739444
Root Mean Square Error	47.69507
Mean of Response	222.0986
Observations (or Sum Wgts)	420

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	32.87	1.1926	0.2827
Acuity Grp	1	1	32.91	5.5776	0.0243
legend	11	11	348.2	0.5660	0.8561
Age Grp*legend	11	11	348.2	0.2820	0.9889
Log 40LI	1	1	348	94.5712	<.0001
Age Grp*Log 40LI	1	1	348.3	5.5078	0.0195
legend*Log 40LI	11	11	351.7	1.0807	0.3758
Acuity Grp*Log 40LI	1	1	348.3	0.4685	0.4941

Table 5 contains the model with statistically significant (at α=0.05) effects as well as the main effect variables that are part of two-way interaction effects. Table 5 suggests that the overall model fit stays almost the same (especially in terms of the adjusted R-square) as the initial model(s). The model in Table 5 can be selected as a final model for Sign 1 with Log 40LI.

Table 5. Output for the Final Model with Log 40LI for Sign 1 without Outliers.

Response leg_dist sign=1

Summary of Fit

RSquare	0.747364
RSquare Adj	0.744929
Root Mean Square Error	47.03036
Mean of Response	222.0986
Observations (or Sum Wgts)	420

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	150.397	12.37397	56.52	12.15	<.0001
Age Grp[0]	15.430152	14.36955	32.8	1.07	0.2907
Acuity Grp[0]	30.987843	13.62745	32.75	2.27	0.0297
Log 40LI	40.568745	3.83272	381.8	10.58	<.0001
Age Grp[0]*(Log 40LI-1.58273)	11.472142	3.83272	381.8	2.99	0.0029

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	32.8	1.1531	0.2907
Acuity Grp	1	1	32.75	5.1707	0.0297
Log 40LI	1	1	381.8	112.0389	<.0001
Age Grp*Log 40LI	1	1	381.8	8.9593	0.0029

Note that Table 5 also shows the estimated model coefficients in the Parameter Estimates table. A prediction equation for Legibility distance (Y) for Sign 1 by Log 40LI can be written using those coefficients as in Equations (1)–(3).

Analysis with CLum_CTime 50LI

Table 6 presents the results under the initial model with CLum_CTime 50LI in place of Aspect of Profile for Sign 1. Because the same outliers as in the case of CLum_CTime 40LI were observed again, they were removed and the model was fitted to the remaining data.

Table 6. Output for the Initial Model with CLum_CTime 50LI for Sign 1 without Seven Outliers.

Response leg_dist sign=1
Summary of Fit

RSquare	0.754435
RSquare Adj	0.729943
Root Mean Square Error	48.55174
Mean of Response	222.0986
Observations (or Sum Wgts)	420

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	32.84	1.1219	0.2972
Acuity Grp	1	1	32.96	5.7969	0.0218
legend	11	11	348.2	0.7295	0.7101
Age Grp*legend	11	11	348.2	0.5869	0.8396
CLum_CTime 50LI	1	1	348	73.8195	<.0001
Age Grp*CLum_CTime 50LI	1	1	348.4	9.9683	0.0017
Acuity Grp*CLum_CTime 50LI	1	1	348.6	1.5106	0.2199
legend*CLum_CTime 50LI	11	11	351.8	1.7559	0.0603

Table 7 contains the model with statistically significant (at α=0.05) effects as well as the main effect variables that are part of two-way interaction effects. Table 7 suggests that the overall model fit stays almost the same (especially in terms of the adjusted R-square) as the initial model(s). The model in Table 7 can be selected as a final model for Sign 1 with CLum_CTime 50LI.

Table 7. Output for the Final Model with CLum_CTime 50LI for Sign 1 without Outliers.

Response leg_dist sign=1
Summary of Fit

RSquare	0.728711
RSquare Adj	0.726096
Root Mean Square Error	48.72711
Mean of Response	222.0986
Observations (or Sum Wgts)	420

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	191.9341	11.05548	36.53	17.36	<.0001
Age Grp[0]	15.285798	14.34624	32.79	1.07	0.2944
Acuity Grp[0]	31.23571	13.60497	32.74	2.30	0.0282
CLum_CTime 50LI	0.1892692	0.021043	381.8	8.99	<.0001
Age Grp[0]*(CLum_CTime 50LI-119.899)	0.0691129	0.021043	381.8	3.28	0.0011

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	32.79	1.1353	0.2944
Acuity Grp	1	1	32.74	5.2712	0.0282
CLum_CTime 50LI	1	1	381.8	80.8958	<.0001
Age Grp*CLum_CTime 50LI	1	1	381.8	10.7866	0.0011

Note that Table 7 also shows the estimated model coefficients in the Parameter Estimates table. A prediction equation for Legibility distance (Y) for Sign 1 by CLum_CTime 50LI can be written using those coefficients as in Equations (1)–(3).

Analysis with Log 50LI

Table 8 presents the results under the initial model with Log 50LI in place of Aspect of Profile for Sign 1. Because the same outliers as in the case of CLum_CTime 40LI were observed again, they were removed and the model was fitted to the remaining data.

Table 8. Output for the Initial Model with Log 50LI for Sign 1 without Seven Outliers.

Response leg_dist sign=1
Summary of Fit

RSquare	0.77456
RSquare Adj	0.752076
Root Mean Square Error	46.53047
Mean of Response	222.0986
Observations (or Sum Wgts)	420

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	32.86	1.1991	0.2815
Acuity Grp	1	1	32.9	5.5879	0.0241
legend	11	11	348.2	0.5871	0.8394
Age Grp*legend	11	11	348.2	0.2975	0.9862
Log 50LI	1	1	348	112.1233	<.0001
Age Grp*Log 50LI	1	1	348.3	5.8451	0.0161
legend*Log 50LI	11	11	351.6	0.9858	0.4588
Acuity Grp*Log 50LI	1	1	348.3	0.3232	0.5700

Table 9 contains the model with statistically significant (at α=0.05) effects as well as the main effect variables that are part of two-way interaction effects. Table 9 suggests that the overall model fit stays almost the same (especially in terms of the adjusted R-square) as the initial model(s). The model in Table 9 can be selected as a final model for Sign 1 with Log 50LI.

Table 9. Output for the Final Model with Log 50LI for Sign 1 without Outliers.

Response leg_dist sign=1
Summary of Fit

RSquare	0.760129
RSquare Adj	0.757817
Root Mean Square Error	45.832
Mean of Response	222.0986
Observations (or Sum Wgts)	420

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	139.13539	12.61791	61.08	11.03	<.0001
Age Grp[0]	15.439539	14.3616	32.81	1.08	0.2902
Acuity Grp[0]	31.01179	13.62012	32.77	2.28	0.0295
Log 50LI	43.070819	3.741369	381.8	11.51	<.0001
Age Grp[0]*(Log 50LI-1.75227)	11.988367	3.74137	381.8	3.20	0.0015

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	32.81	1.1557	0.2902
Acuity Grp	1	1	32.77	5.1843	0.0295
Log 50LI	1	1	381.8	132.5272	<.0001
Age Grp*Log 50LI	1	1	381.8	10.2674	0.0015

Note that Table 9 also shows the estimated model coefficients in the Parameter Estimates table. A prediction equation for Legibility distance (Y) for Sign 1 by Log 50LI can be written using those coefficients as in Equations (1)–(3).

Analysis with CLum_CTime 80LI

Table 10 presents the results under the initial model with CLum_CTime 80LI in place of Aspect of Profile for Sign 1. Because the same outliers as in the case of CLum_CTime 40LI were observed again, they were removed and the model was fitted to the remaining data.

Table 10. Output for the Initial Model with CLum_CTime 80LI for Sign 1 without Seven Outliers.

Response leg_dist sign=1
Summary of Fit

RSquare	0.765874
RSquare Adj	0.742522
Root Mean Square Error	47.41323
Mean of Response	222.0986
Observations (or Sum Wgts)	420

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	32.85	1.1595	0.2894
Acuity Grp	1	1	32.95	5.7652	0.0221
legend	11	11	348.2	0.7622	0.6778
Age Grp*legend	11	11	348.2	0.6469	0.7881
CLum_CTime 80LI	1	1	348	89.9684	<.0001
Age Grp*CLum_CTime 80LI	1	1	348.2	10.5403	0.0013
Acuity Grp*CLum_CTime 80LI	1	1	348.4	1.1466	0.2850
legend*CLum_CTime 80LI	11	11	351.7	1.7247	0.0665

Table 11 contains the model with statistically significant (at α=0.05) effects as well as the main effect variables that are part of two-way interaction effects. Table 11 suggests that the overall model fit stays almost the same (especially in terms of the adjusted R-square) as the initial model(s). The model in Table 11 can be selected as a final model for Sign 1 with CLum_CTime 80LI.

Table 11. Output for the Final Model with CLum_CTime 80LI for Sign 1 without Outliers.

Response leg_dist sign=1
Summary of Fit

RSquare	0.741118
RSquare Adj	0.738623
Root Mean Square Error	47.60501
Mean of Response	222.0986
Observations (or Sum Wgts)	420

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	189.34045	11.05834	36.67	17.12	<.0001
Age Grp[0]	15.282024	14.33742	32.8	1.07	0.2943
Acuity Grp[0]	31.280066	13.59681	32.75	2.30	0.0279
CLum_CTime 80LI	0.1376146	0.013933	381.8	9.88	<.0001
Age Grp[0]*(CLum_CTime 80LI-183.774)	0.0487724	0.013933	381.8	3.50	0.0005

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	32.8	1.1361	0.2943
Acuity Grp	1	1	32.75	5.2925	0.0279
CLum_CTime 80LI	1	1	381.8	97.5469	<.0001
Age Grp*CLum_CTime 80LI	1	1	381.8	12.2527	0.0005

Note that Table 11 also shows the estimated model coefficients in the Parameter Estimates table. A prediction equation for Legibility distance (Y) for sign 1 by CLum_CTime 80LI can be written using those coefficients as in Equations (1)–(3).

Analysis with Log 80LI

Table 12 presents the results under the initial model with Log 80LI in place of Aspect of Profile for Sign 1. Because the same outliers as in the case of CLum_CTime 40LI were observed again, they were removed and the model was fitted to the remaining data.

Table 12. Output for the Initial Model with Log 80LI for Sign 1 without Seven Outliers.

Response leg_dist sign=1
Summary of Fit

RSquare	0.785465
RSquare Adj	0.764068
Root Mean Square Error	45.3966
Mean of Response	222.0986
Observations (or Sum Wgts)	420

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	32.86	1.1978	0.2817
Acuity Grp	1	1	32.89	5.6160	0.0238
legend	11	11	348.2	0.6186	0.8130
Log 80LI	1	1	348	129.1700	<.0001
Age Grp*legend	11	11	348.2	0.3357	0.9774
Age Grp*Log 80LI	1	1	348.2	6.7669	0.0097
Acuity Grp*Log 80LI	1	1	348.2	0.2575	0.6122
legend*Log 80LI	11	11	351.4	0.9500	0.4923

Table 13 contains the model with statistically significant (at α=0.05) effects as well as the main effect variables that are part of two-way interaction effects. Table 13 suggests that the overall model fit stays almost the same (especially in terms of the adjusted R-square) as the initial model(s). The model in Table 13 can be selected as a final model for Sign 1 with Log 80LI.

Table 13. Output for the Final Model with Log 80LI for Sign 1 without Outliers.

Response leg_dist sign=1
Summary of Fit

RSquare	0.771467
RSquare Adj	0.769265
Root Mean Square Error	44.74012
Mean of Response	222.0986
Observations (or Sum Wgts)	420

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	114.91478	13.47412	78.43	8.53	<.0001
Age Grp[0]	15.428584	14.35281	32.82	1.07	0.2902
Acuity Grp[0]	31.058378	13.61197	32.78	2.28	0.0291
Log 80LI	50.264454	4.076799	381.8	12.33	<.0001
Age Grp[0]*(Log 80LI-1.98344)	14.100073	4.076801	381.8	3.46	0.0006

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	32.82	1.1555	0.2902
Acuity Grp	1	1	32.78	5.2061	0.0291
Log 80LI	1	1	381.8	152.0139	<.0001
Age Grp*Log 80LI	1	1	381.8	11.9620	0.0006

Note that Table 13 also shows the estimated model coefficients in the Parameter Estimates table. A prediction equation for Legibility distance (Y) for Sign 1 by Log 80LI can be written using those coefficients as in Equations (1)–(3).

ANALYSIS FOR SIGN 2

Analysis with CLum_CTime 40LI

Table 14 presents the results under the initial model with CLum_CTime 40LI in place of Aspect of Profile for Sign 2.

Table 14. Output for the Initial Model with CLum_CTime 40LI for Sign 2.

Response leg_dist sign=2
Summary of Fit

RSquare	0.77956
RSquare Adj	0.758081
Root Mean Square Error	79.05732
Mean of Response	408.7219
Observations (or Sum Wgts)	429

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	33.03	2.0426	0.1623
Acuity Grp	1	1	32.94	6.4656	0.0159
legend	11	11	357.1	1.1184	0.3454
Age Grp*legend	11	11	357.2	0.5101	0.8965
CLum_CTime 40LI	1	1	357.3	52.7399	<.0001
Age Grp*CLum_CTime 40LI	1	1	357.7	3.0730	0.0805
Acuity Grp*CLum_CTime 40LI	1	1	357.4	0.0115	0.9146
legend*CLum_CTime 40LI	11	11	360.8	0.9905	0.4545

The effect of CLum_CTime 40LI on the legibility distance is positive, i.e., as CLum_CTime 40LI increases, the legibility distance increases, although the coefficient is not shown in the table. The residual plot is given in Figure 8, which indicates that the underlying model assumptions are generally satisfied.

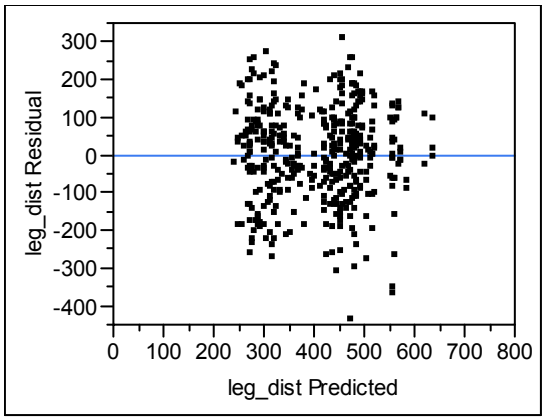


Figure 8. Residual by Predicted Plot for the Initial Model with CLum_CTime 40LI for Sign 2.

An effort has been made to select a more parsimonious model while maintaining good overall model fit. Because the interaction effect Age Grp*CLum_CTime 40LI became significant at α=0.05 as soon as one of the least significant terms, AcuityGrp*CLum_CTime 40LI, was removed from the model, the term Age Grp*CLum_CTime 40LI was decided to be kept in the final model. Table 15 contains the model with statistically significant (at α=0.05) effects as well as the main effect variables that are part of two-way interaction effects. It can be seen that the overall model fit stays almost the same (especially in terms of the adjusted R-square) as the initial model(s).

Table 15. Output for the Final Model with CLum_CTime 40LI for Sign 2.

Response leg_dist sign=2

Summary of Fit

RSquare	0.761892
RSquare Adj	0.759646
Root Mean Square Error	78.53739
Mean of Response	408.7219
Observations (or Sum Wgts)	429

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	360.78866	18.89517	35.91	19.09	<.0001
Age Grp[0]	34.074443	24.66653	33	1.38	0.1764
Acuity Grp[0]	59.975283	23.40114	33	2.56	0.0151
CLum_CTime 40LI	0.2153271	0.027899	391	7.72	<.0001
Age Grp[0]*(CLum_CTime 40LI-137.675)	0.0758134	0.027899	391	2.72	0.0069

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	33	1.9083	0.1764
Acuity Grp	1	1	33	6.5686	0.0151
CLum_CTime 40LI	1	1	391	59.5670	<.0001
Age Grp*CLum_CTime 40LI	1	1	391	7.3841	0.0069

Table 15 also shows the estimated model coefficients in the Parameter Estimates table. A prediction equation for Legibility distance (Y) for Sign 2 can be written using those coefficients (if desired) as follows:

$$Y=360.78866+34.074443\ \text{Age Grp[0]} + 59.975283\ \text{Acuity Grp[0]} +0.2153271\ \text{CLum_CTime 40LI} +0.0758134\ \text{Age Grp[0]}*(\text{CLum_CTime 40LI}-82.1944) \quad (4)$$

where Age Grp[0] and Acuity Grp[0] are indicator functions as defined previously.

Equation (4) can be simplified by replacing the indicator function by either 0 or 1 depending on whether the condition is satisfied. For example, when Age Group = 0 and Acuity Group = 0, Equation (4) can be rewritten as:

$$Y=360.78866+34.074443 + 59.975283 +0.2153271\ \text{CLum_CTime 40LI} +0.0758134\ *(\text{CLum_CTime 40LI}-82.1944)$$

$$= 448.6069+ 0.2911\ \text{CLum_CTime 40LI} \quad (5)$$

and when Age Group = 1 and Acuity Group = 1, Equation (1) can be rewritten as:

$$Y=360.78866+0.2153271\ \text{CLum_CTime 40LI} \quad (6)$$

From Equations (5) and (6), it can be seen that the rate of increase (slope for CLum_CTime 40LI) of legibility distance (as CLum_CTime 40LI increases) is larger for young drivers than for old drivers as the significant interaction effect Age Grp*CLum_CTime 40LI suggests.

Analysis with Log 40LI

Table 16 presents the results under the initial model with Log 40LI in place of Aspect of Profile for Sign 2.

Table 16. Output for the Initial Model with Log 40LI for Sign 2.

Response leg_dist sign=2
Summary of Fit

RSquare	0.796165
RSquare Adj	0.776304
Root Mean Square Error	76.03694
Mean of Response	408.7219
Observations (or Sum Wgts)	429

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	33.02	1.9484	0.1721
Acuity Grp	1	1	32.95	6.5091	0.0156
legend	11	11	357.1	1.2668	0.2419
Log 40LI	1	1	357.2	86.3257	<.0001
Age Grp*legend	11	11	357.2	0.7143	0.7249
Age Grp*Log 40LI	1	1	357.4	2.3937	0.1227
legend*Log 40LI	11	11	360.4	0.4565	0.9288
Acuity Grp*Log 40LI	1	1	357.1	0.1652	0.6846

Because the interaction effect Age Grp*Log 40LI became significant at α=0.05 when Acuity Grp*Log 40LI was removed from the model, the term Age Grp* Log 40LI was decided to be kept in the final model. Table 17 contains the model with statistically significant (at α=0.05) effects as well as the main effect variables that are part of two-way interaction effects. It can be seen that the overall model fit stays almost the same (especially in terms of the adjusted R-square) as the initial model(s).

Table 17. Output for the Final Model with Log 40LI for Sign 2.

Response leg_dist sign=2
Summary of Fit

RSquare	0.780223
RSquare Adj	0.77815
Root Mean Square Error	75.46567
Mean of Response	408.7219
Observations (or Sum Wgts)	429

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	287.32572	21.42824	58.66	13.41	<.0001
Age Grp[0]	34.270851	24.68391	33	1.39	0.1743
Acuity Grp[0]	59.898937	23.41758	33	2.56	0.0153
Log 40LI	57.468982	6.005419	391	9.57	<.0001
Age Grp[0]*(Log 40LI-1.79375)	16.45767	6.00542	391	2.74	0.0064

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	33	1.9276	0.1743
Acuity Grp	1	1	33	6.5427	0.0153
Log 40LI	1	1	391	91.5757	<.0001
Age Grp*Log 40LI	1	1	391	7.5102	0.0064

Note that Table 17 also shows the estimated model coefficients in the Parameter Estimates table. A prediction equation for Legibility distance (Y) for Sign 2 by Log 40LI can be written using those coefficients as in Equations (4)-(6).

Analysis with CLum_CTime 50LI

Table 18 presents the results under the initial model with CLum_CTime 50LI in place of Aspect of Profile for Sign 2.

Table 18. Output for the Initial Model with CLum_CTime 50LI for Sign 2.

Response leg_dist sign=2
Summary of Fit

RSquare	0.791035
RSquare Adj	0.770674
Root Mean Square Error	76.98181
Mean of Response	408.7219
Observations (or Sum Wgts)	429

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	33.03	2.0542	0.1612
Acuity Grp	1	1	32.96	6.4749	0.0158
legend	11	11	357.1	1.1365	0.3314
Age Grp*legend	11	11	357.2	0.5495	0.8687
CLum_CTime 50LI	1	1	357.3	63.5166	<.0001
Age Grp*CLum_CTime 50LI	1	1	357.6	5.7376	0.0171
Acuity Grp*CLum_CTime 50LI	1	1	357.3	0.0953	0.7577
legend*CLum_CTime 50LI	11	11	360.5	1.1212	0.3431

Table 19 contains the model with statistically significant (at α=0.05) effects as well as the main effect variables that are part of two-way interaction effects. Table 19 suggests that the overall model fit stays almost the same (especially in terms of the adjusted R-square) as the initial model(s). The model in Table 19 can be selected as a final model for Sign 2 with CLum_CTime 50LI.

Table 19. Output for the Final Model with CLum_CTime 50LI for Sign 2.

Response leg_dist sign=2
Summary of Fit

RSquare	0.772977
RSquare Adj	0.770835
Root Mean Square Error	76.69457
Mean of Response	408.7219
Observations (or Sum Wgts)	429

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	358.10706	18.88103	35.86	18.97	<.0001
Age Grp[0]	33.952614	24.65633	33	1.38	0.1778
Acuity Grp[0]	60.12349	23.39145	33	2.57	0.0149
CLum_CTime 50LI	0.1559319	0.018373	391	8.49	<.0001
Age Grp[0]*(CLum_CTime 50LI-207.427)	0.0607935	0.018373	391	3.31	0.0010

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	33	1.8962	0.1778
Acuity Grp	1	1	33	6.6065	0.0149
CLum_CTime 50LI	1	1	391	72.0319	<.0001
Age Grp*CLum_CTime 50LI	1	1	391	10.9489	0.0010

Note that Table 19 also shows the estimated model coefficients in the Parameter Estimates table. A prediction equation for Legibility distance (Y) for sign 2 by CLum_CTime 50LI can be written using those coefficients as in Equations (4)–(6).

Analysis with Log 50LI

Table 20 presents the results under the initial model with Log 50LI in place of Aspect of Profile for Sign 2.

Table 20. Output for the Initial Model with Log 50LI for Sign 2.

Response leg_dist sign=2
Summary of Fit

RSquare	0.807474
RSquare Adj	0.788715
Root Mean Square Error	73.90729
Mean of Response	408.7219
Observations (or Sum Wgts)	429

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	33.01	1.9140	0.1758
Acuity Grp	1	1	32.96	6.5113	0.0155
legend	11	11	357.1	1.2995	0.2226
Age Grp*legend	11	11	357.2	0.7846	0.6556
Log 50LI	1	1	357.2	100.9192	<.0001
Age Grp*Log 50LI	1	1	357.3	4.3620	0.0375
Acuity Grp*Log 50LI	1	1	357.1	0.0581	0.8097
legend*Log 50LI	11	11	360.1	0.4642	0.9245

Table 21 contains the model with statistically significant (at α=0.05) effects as well as the main effect variables that are part of two-way interaction effects. Table 21 suggests that the overall model fit stays almost the same (especially in terms of the adjusted R-square) as the initial model(s). The model in Table 21 can be selected as a final model for Sign 2 with Log 50LI.

Table 21. Output for the Final Model with Log 50LI for Sign 2.

Response leg_dist sign=2
Summary of Fit

RSquare	0.791468
RSquare Adj	0.789501
Root Mean Square Error	73.51663
Mean of Response	408.7219
Observations (or Sum Wgts)	429

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	269.7618	21.86961	63.52	12.34	<.0001
Age Grp[0]	34.139014	24.67396	33	1.38	0.1758
Acuity Grp[0]	60.068166	23.40813	33	2.57	0.0150
Log 50LI	60.902671	5.873772	391	10.37	<.0001
Age Grp[0]*(Log 50LI-1.98143)	19.423777	5.873772	391	3.31	0.0010

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	33	1.9144	0.1758
Acuity Grp	1	1	33	6.5850	0.0150
Log 50LI	1	1	391	107.5074	<.0001
Age Grp*Log 50LI	1	1	391	10.9354	0.0010

Note that Table 21 also shows the estimated model coefficients in the Parameter Estimates table. A prediction equation for Legibility distance (Y) for Sign 2 by Log 50LI can be written using those coefficients as in Equations (4)–(6).

Analysis with CLum_CTime 80LI

Table 22 presents the results under the initial model with CLum_CTime 80LI in place of Aspect of Profile for Sign 2.

Table 22. Output for the Initial Model with CLum_CTime 80LI for Sign 2.

Response leg_dist sign=2
Summary of Fit

RSquare	0.798846
RSquare Adj	0.779246
Root Mean Square Error	75.53595
Mean of Response	408.7219
Observations (or Sum Wgts)	429

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	33.03	2.0503	0.1616
Acuity Grp	1	1	32.97	6.4829	0.0157
legend	11	11	357.1	1.1302	0.3362
Age Grp*legend	11	11	357.2	0.5854	0.8408
CLum_CTime 80LI	1	1	357.3	71.2787	<.0001
Age Grp*CLum_CTime 80LI	1	1	357.5	8.2034	0.0044
Acuity Grp*CLum_CTime 80LI	1	1	357.2	0.1960	0.6582
legend*CLum_CTime 80LI	11	11	360.3	1.2100	0.2784

Table 23 contains the model with statistically significant (at α=0.05) effects as well as the main effect variables that are part of two-way interaction effects. Table 23 suggests that the overall model fit stays almost the same (especially in terms of the adjusted R-square) as the initial model(s). The model in Table 23 can be selected as a final model for Sign 2 with CLum_CTime 80LI.

Table 23. Output for the Final Model with CLum_CTime 80LI for Sign 2.

Response leg_dist sign=2
Summary of Fit

RSquare	0.780573
RSquare Adj	0.778503
Root Mean Square Error	75.40546
Mean of Response	408.7219
Observations (or Sum Wgts)	429

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	356.12838	18.87556	35.87	18.87	<.0001
Age Grp[0]	33.842602	24.64729	33	1.37	0.1790
Acuity Grp[0]	60.247894	23.38286	33	2.58	0.0146
CLum_CTime 80LI	0.1078561	0.011997	391	8.99	<.0001
Age Grp[0]*(CLum_CTime 80LI-318.351)	0.0448801	0.011997	391	3.74	0.0002

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	33	1.8853	0.1790
Acuity Grp	1	1	33	6.6388	0.0146
CLum_CTime 80LI	1	1	391	80.8253	<.0001
Age Grp*CLum_CTime 80LI	1	1	391	13.9948	0.0002

Note that Table 23 also shows the estimated model coefficients in the Parameter Estimates table. A prediction equation for Legibility distance (Y) for Sign 2 by CLum_CTime 80LI can be written using those coefficients as in Equations (4)–(6).

Analysis with Log 80LI

Table 24 presents the results under the initial model with Log 80LI in place of Aspect of Profile for Sign 2.

Table 24. Output for the Initial Model with Log 80LI for Sign 2.

Response leg_dist sign=2
Summary of Fit

RSquare	0.815606
RSquare Adj	0.79764
Root Mean Square Error	72.33627
Mean of Response	408.7219
Observations (or Sum Wgts)	429

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	33.01	1.9009	0.1772
Acuity Grp	1	1	32.97	6.5059	0.0156
legend	11	11	357.1	1.3109	0.2161
Age Grp*legend	11	11	357.2	0.8274	0.6126
Log 80LI	1	1	357.1	111.1166	<.0001
Age Grp*Log 80LI	1	1	357.3	6.5511	0.0109
Acuity Grp*Log 80LI	1	1	357.1	0.0051	0.9428
legend*Log 80LI	11	11	360	0.4996	0.9033

Table 25 contains the model with statistically significant (at α=0.05) effects as well as the main effect variables that are part of two-way interaction effects. Table 25 suggests that the overall model fit stays almost the same (especially in terms of the adjusted R-square) as the initial model(s). The model in Table 25 can be selected as a final model for Sign 2 with Log 80LI.

Table 25. Output for the Final Model with Log 80LI for Sign 2.

Response leg_dist sign=2
Summary of Fit

RSquare	0.799524
RSquare Adj	0.797632
Root Mean Square Error	72.08758
Mean of Response	408.7219
Observations (or Sum Wgts)	429

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	240.61683	23.04453	77.51	10.44	<.0001
Age Grp[0]	34.013686	24.66266	33	1.38	0.1771
Acuity Grp[0]	60.190365	23.3974	33	2.57	0.0148
Log 80LI	68.078657	6.238971	391	10.91	<.0001
Age Grp[0]*(Log 80LI-2.20094)	23.583471	6.238971	391	3.78	0.0002

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	33	1.9021	0.1771
Acuity Grp	1	1	33	6.6179	0.0148
Log 80LI	1	1	391	119.0682	<.0001
Age Grp*Log 80LI	1	1	391	14.2886	0.0002

Note that Table 25 also shows the estimated model coefficients in the Parameter Estimates table. A prediction equation for Legibility distance (Y) for Sign 2 by Log 80LI can be written using those coefficients as in Equations (4)–(6).

ANALYSIS FOR SIGN 3

Analysis with CLum_CTime 40LI

Table 26 presents the results under the initial model with CLum_CTime 40LI in place of Aspect of Profile for Sign 3.

Table 26. Output for the Initial Model with CLum_CTime 40LI for Sign 3.

Response leg_dist sign=3
Summary of Fit

RSquare	0.816749
RSquare Adj	0.798036
Root Mean Square Error	75.37208
Mean of Response	401.8678
Observations (or Sum Wgts)	314

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	33.05	0.9588	0.3346
Acuity Grp	1	1	33.11	4.7203	0.0371
legend	8	8	251.2	1.0370	0.4086
Age Grp*legend	8	8	251.3	1.2425	0.2747
CLum_CTime 40LI	1	1	251.7	40.4736	<.0001
Age Grp*CLum_CTime 40LI	1	1	252.2	3.6346	0.0577
Acuity Grp*CLum_CTime 40LI	1	1	251.9	0.2524	0.6158
legend*CLum_CTime 40LI	8	8	255.2	0.9166	0.5031

The effect of CLum_CTime 40LI on the legibility distance is positive, i.e., as CLum_CTime 40LI increases, the legibility distance increases, although the coefficient is not shown in the table. The residual plot is given in Figure 9, which indicates that the underlying model assumptions are generally satisfied.

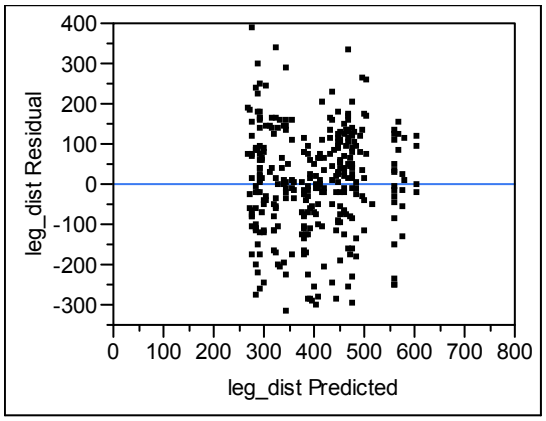


Figure 9. Residual by Predicted Plot for the Initial Model with CLum_CTime 40LI for Sign 3.

An effort has been made to select a more parsimonious model while maintaining good overall model fit. Because the interaction effect Age Grp*CLum_CTime 40LI became significant at α=0.05 as soon as one of the least significant terms, AcuityGrp*CLum_CTime 40LI, was removed from the model, the term Age Grp*CLum_CTime 40LI was decided to be kept in the final model. Table 27 contains the model with statistically significant (at α=0.05) effects as well as the main effect variables that are part of two-way interaction effects. It can be

seen that the overall model fit stays almost the same (especially in terms of the adjusted R-square) as the initial model(s).

Table 27. Output for the Final Model with CLum_CTime 40LI for Sign 3.

Response leg_dist sign=3

Summary of Fit

RSquare	0.795565
RSquare Adj	0.792919
Root Mean Square Error	75.95521
Mean of Response	401.8678
Observations (or Sum Wgts)	314

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	356.94469	21.33844	36.12	16.73	<.0001
Age Grp[0]	25.28013	27.80342	32.96	0.91	0.3698
Acuity Grp[0]	56.068565	26.37825	32.97	2.13	0.0411
CLum_CTime 40LI	0.3569204	0.052295	276.6	6.83	<.0001
Age Grp[0]*(CLum_CTime 40LI-84.8283)	0.1743704	0.052298	276.5	3.33	0.0010

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	32.96	0.8267	0.3698
Acuity Grp	1	1	32.97	4.5180	0.0411
CLum_CTime 40LI	1	1	276.6	46.5817	<.0001
Age Grp*CLum_CTime 40LI	1	1	276.5	11.1168	0.0010

Table 27 also shows the estimated model coefficients in the Parameter Estimates table. A prediction equation for Legibility distance (Y) for Sign 3 can be written using those coefficients (if desired) as in Equations (1)–(6). Note that a significant interaction effect Age Grp*CLum_CTime 40LI suggests that the rate of increase (slope for CLum_CTime 40LI) of legibility distance (as CLum_CTime 40LI increases) is different for young drivers and old drivers. From the positive coefficient for the interaction term Age Grp*CLum_CTime 40LI shown in the Parameter Estimates table, it can be concluded that the rate of increase (slope for CLum_CTime 40LI) is larger for young drivers than for old drivers.

Analysis with Log 40LI

Table 28 presents the results under the initial model with Log 40LI in place of Aspect of Profile for Sign 3.

Table 28. Output for the Initial Model with Log 40LI for Sign 3.

Response leg_dist sign=3
Summary of Fit

RSquare	0.834047
RSquare Adj	0.817101
Root Mean Square Error	71.75196
Mean of Response	401.8678
Observations (or Sum Wgts)	314

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	32.92	0.8260	0.3700
Acuity Grp	1	1	33	4.7434	0.0367
legend	8	8	251.2	1.0527	0.3971
Log 40LI	1	1	251.6	64.6581	<.0001
Age Grp*legend	8	8	251.3	1.0120	0.4273
Age Grp*Log 40LI	1	1	252.1	1.2203	0.2703
Acuity Grp*Log 40LI	1	1	251.9	3.6604	0.0569
legend*Log 40LI	8	8	254.5	0.7033	0.6886

Because the interaction effect Acuity Grp*Log 40LI became significant at α=0.05 when legend*Log 40LI was removed from the model, the term Acuity Grp* Log 40LI (not Age Grp* Log 40LI unlike the previous models) was decided to be kept in the final model. Table 29 contains the model with statistically significant (at α=0.05) effects as well as the main effect variables that are part of two-way interaction effects. It can be seen that the overall model fit stays almost the same (especially in terms of the adjusted R-square) as the initial model(s).

Table 29. Output for the Final Model with Log 40LI for Sign 3.

Response leg_dist sign=3
Summary of Fit

RSquare	0.817774
RSquare Adj	0.816011
Root Mean Square Error	71.72791
Mean of Response	401.8678
Observations (or Sum Wgts)	314

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	293.10985	22.03386	54.47	13.30	<.0001
Acuity Grp[0]	72.749527	19.54176	34.03	3.72	0.0007
Log 40LI	62.897745	6.402691	276.5	9.82	<.0001
Acuity Grp[0]*(Log 40LI-1.59292)	27.153958	6.402691	276.5	4.24	<.0001

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Acuity Grp	1	1	34.03	13.8590	0.0007
Log 40LI	1	1	276.5	96.5039	<.0001
Acuity Grp*Log 40LI	1	1	276.5	17.9863	<.0001

Table 29 also shows the estimated model coefficients in the Parameter Estimates table. A prediction equation for Legibility distance (Y) for Sign 3 by Log 40LI can be written using those coefficients (if desired) as follows:

$$Y=293.10985+ 72.749527 \text{ Acuity Grp}[0] +62.897745 \text{ Log 40LI}$$
$$+27.153958 \text{ Acuity Grp}[0]*(\text{Log 40LI}-1.59292) \quad (7)$$

where Acuity Grp[0] is an indicator function as defined previously.

Equation (7) can be simplified by replacing Acuity Grp[0] by 0 when Acuity Group = 1 or 1 when Acuity Group = 0. When Acuity Group = 0, Equation (7) can be rewritten as:

$$Y=293.10985+ 72.749527 +62.897745 \text{ Log 40LI}+27.153958 *(\text{Log 40LI}-1.59292)$$
$$= 322.6053+ 90.0517 \text{ Log 40LI} \quad (8)$$

and when Acuity Group = 1, Equation (7) becomes:

$$Y=293.10985+ 62.897745 \text{ Log 40LI} \quad (9)$$

From Equations (8) and (9), it can be seen that the rate of increase (slope for Log 40LI) of legibility distance (as Log 40LI increases) is larger for the drivers with good vision than for the drivers with poor vision as the significant interaction effect Acuity Grp* Log 40LI suggests.

Analysis with CLum_CTime 50LI

Table 30 presents the results under the initial model with CLum_CTime 50LI in place of Aspect of Profile for Sign 3.

Table 30. Output for the Initial Model with CLum_CTime 50LI for Sign 3.

Response leg_dist sign=3
Summary of Fit

RSquare	0.822163
RSquare Adj	0.804004
Root Mean Square Error	74.26033
Mean of Response	401.8678
Observations (or Sum Wgts)	314

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	33.04	0.9206	0.3443
Acuity Grp	1	1	33.14	4.7501	0.0365
legend	8	8	251.2	1.0016	0.4353
Age Grp*legend	8	8	251.3	1.2762	0.2562
CLum_CTime 50LI	1	1	251.7	45.3171	<.0001
Age Grp*CLum_CTime 50LI	1	1	252.1	3.3314	0.0692
Acuity Grp*CLum_CTime 50LI	1	1	252	0.6767	0.4115
legend*CLum_CTime 50LI	8	8	254.8	0.8757	0.5375

Because the interaction effect Age Grp*CLum_CTime 50LI became significant at α=0.05 when Acuity Grp*CLum_CTime 50LI was removed from the model, the term Age Grp*CLum_CTime 50LI was decided to be kept in the final model. Table 31 contains the final model with statistically significant (at α=0.05) effects as well as the main effect variables that are part of two-way interaction effects. Table 31 suggests that the overall model fit stays almost the same (especially in terms of the adjusted R-square) as the initial model(s).

Table 31. Output for the Final Model with CLum_CTime 50LI for Sign 3.

Response leg_dist sign=3

Summary of Fit

RSquare	0.801297
RSquare Adj	0.798725
Root Mean Square Error	74.88963
Mean of Response	401.8678
Observations (or Sum Wgts)	314

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	355.30205	21.37032	36.09	16.63	<.0001
Age Grp[0]	25.522273	27.85154	32.96	0.92	0.3661
Acuity Grp[0]	55.705924	26.42397	32.97	2.11	0.0427
CLum_CTime 50LI	0.2576249	0.035735	276.6	7.21	<.0001
Age Grp[0]*(CLum_CTime 50LI-123.692)	0.1290536	0.035737	276.5	3.61	0.0004

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	32.96	0.8397	0.3661
Acuity Grp	1	1	32.97	4.4443	0.0427
CLum_CTime 50LI	1	1	276.6	51.9734	<.0001
Age Grp*CLum_CTime 50LI	1	1	276.5	13.0411	0.0004

Note that Table 31 also shows the estimated model coefficients in the Parameter Estimates table. A prediction equation for Legibility distance (Y) for Sign 3 by CLum_CTime 50LI can be written using those coefficients as in Equations (1)–(9).

Analysis with Log 50LI

Table 32 presents the results under the initial model with Log 50LI in place of Aspect of Profile for Sign 3.

Table 32. Output for the Initial Model with Log 50LI for Sign 3.

Response leg_dist sign=3
Summary of Fit

RSquare	0.839537
RSquare Adj	0.823152
Root Mean Square Error	70.56431
Mean of Response	401.8678
Observations (or Sum Wgts)	314

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	32.92	0.8059	0.3759
Acuity Grp	1	1	33.02	4.6719	0.0380
legend	8	8	251.2	1.0289	0.4146
Log 50LI	1	1	251.6	71.9311	<.0001
Age Grp*legend	8	8	251.3	1.0232	0.4189
Age Grp*Log 50LI	1	1	251.9	0.9995	0.3184
Acuity Grp*Log 50LI	1	1	251.9	5.2562	0.0227
legend*Log 50LI	8	8	254.2	0.6091	0.7699

Table 33 contains the model with statistically significant (at α=0.05) effects as well as the main effect variables that are part of two-way interaction effects. Table 33 suggests that the overall model fit stays almost the same (especially in terms of the adjusted R-square) as the initial model(s). The model in Table 33 can be selected as a final model for Sign 3 with Log 50LI.

Table 33. Output for the Final Model with Log 50LI for Sign 3.

Response leg_dist sign=3
Summary of Fit

RSquare	0.824622
RSquare Adj	0.822925
Root Mean Square Error	70.37519
Mean of Response	401.8678
Observations (or Sum Wgts)	314

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	278.56222	22.51145	58.53	12.37	<.0001
Acuity Grp[0]	72.611813	19.59183	34.03	3.71	0.0007
Log 50LI	65.059524	6.303225	276.6	10.32	<.0001
Acuity Grp[0]*(Log 50LI-1.76233)	29.585122	6.303225	276.6	4.69	<.0001

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Acuity Grp	1	1	34.03	13.7361	0.0007
Log 50LI	1	1	276.6	106.5359	<.0001
Acuity Grp*Log 50LI	1	1	276.6	22.0303	<.0001

Note that Table 33 also shows the estimated model coefficients in the Parameter Estimates table. A prediction equation for Legibility distance (Y) for Sign 3 by Log 50LI can be written using those coefficients as in Equations (7)–(9).

Analysis with CLum_CTime 80LI

Table 34 presents the results under the initial model with CLum_CTime 80LI in place of Aspect of Profile for Sign 3.

Table 34. Output for the Initial Model with CLum_CTime 80LI for Sign 3.

Response leg_dist sign=3
Summary of Fit

RSquare	0.825675
RSquare Adj	0.807874
Root Mean Square Error	73.53144
Mean of Response	401.8678
Observations (or Sum Wgts)	314

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	33.04	0.8624	0.3598
Acuity Grp	1	1	33.2	4.8284	0.0351
legend	8	8	251.2	0.9546	0.4722
Age Grp*legend	8	8	251.3	1.2972	0.2453
CLum_CTime 80LI	1	1	251.7	48.9366	<.0001
Age Grp*CLum_CTime 80LI	1	1	252	2.5532	0.1113
Acuity Grp*CLum_CTime 80LI	1	1	252.1	1.5550	0.2136
legend*CLum_CTime 80LI	8	8	254.6	0.8161	0.5890

Because the interaction effect Age Grp*CLum_CTime 80LI became significant at α=0.05 when Acuity Grp*CLum_CTime 80LI was removed from the model, the term Age Grp*CLum_CTime 80LI was decided to be kept in the final model. Table 35 contains the final model with statistically significant (at α=0.05) effects as well as the main effect variables that are part of two-way interaction effects. Table 35 suggests that the overall model fit stays almost the same (especially in terms of the adjusted R-square) as the initial model(s).

Table 35. Output for the Final Model with CLum_CTime 80LI for Sign 3.

Response leg_dist sign=3
Summary of Fit

RSquare	0.80489
RSquare Adj	0.802365
Root Mean Square Error	74.21408
Mean of Response	401.8678
Observations (or Sum Wgts)	314

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	354.35999	21.4144	36.05	16.55	<.0001
Age Grp[0]	25.700449	27.91808	32.96	0.92	0.3640
Acuity Grp[0]	55.44791	26.48715	32.97	2.09	0.0441
CLum_CTime 80LI	0.1632592	0.021902	276.6	7.45	<.0001
Age Grp[0]*(CLum_CTime 80LI-200.712)	0.0827622	0.021902	276.6	3.78	0.0002

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	32.96	0.8474	0.3640
Acuity Grp	1	1	32.97	4.3823	0.0441
CLum_CTime 80LI	1	1	276.6	55.5647	<.0001
Age Grp*CLum_CTime 80LI	1	1	276.6	14.2785	0.0002

Note that Table 35 also shows the estimated model coefficients in the Parameter Estimates table. A prediction equation for Legibility distance (Y) for Sign 3 by CLum_CTime 80LI can be written using those coefficients as in Equations (4)–(6).

Analysis with Log 80LI

Table 36 presents the results under the initial model with Log 80LI in place of Aspect of Profile for Sign 3.

Table 36. Output for the Initial Model with Log 80LI for Sign 3.

Response leg_dist sign=3
Summary of Fit

RSquare	0.844098
RSquare Adj	0.828178
Root Mean Square Error	69.56259
Mean of Response	401.8678
Observations (or Sum Wgts)	314

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	32.91	0.7933	0.3796
Acuity Grp	1	1	33.05	4.5950	0.0395
legend	8	8	251.2	0.9950	0.4404
Age Grp*legend	8	8	251.3	1.0342	0.4106
Log 80LI	1	1	251.6	77.9942	<.0001
Age Grp*Log 80LI	1	1	251.7	0.7629	0.3833
Acuity Grp*Log 80LI	1	1	251.8	7.1806	0.0079
legend*Log 80LI	8	8	254	0.4944	0.8597

Table 37 contains the model with statistically significant (at α=0.05) effects as well as the main effect variables that are part of two-way interaction effects. Table 37 suggests that the overall model fit stays almost the same (especially in terms of the adjusted R-square) as the initial model(s). The model in Table 37 can be selected as a final model for Sign 3 with Log 80LI.

Table 37. Output for the Final Model with Log 80LI for Sign 3.

Response leg_dist sign=3
Summary of Fit

RSquare	0.830547
RSquare Adj	0.828907
Root Mean Square Error	69.18309
Mean of Response	401.8678
Observations (or Sum Wgts)	314

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	251.94929	23.64853	69.59	10.65	<.0001
Acuity Grp[0]	72.44109	19.64904	34.03	3.69	0.0008
Log 80LI	70.72764	6.605026	276.6	10.71	<.0001
Acuity Grp[0]*(Log 80LI-1.99579)	34.180882	6.605026	276.6	5.17	<.0001

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Acuity Grp	1	1	34.03	13.5921	0.0008
Log 80LI	1	1	276.6	114.6646	<.0001
Acuity Grp*Log 80LI	1	1	276.6	26.7804	<.0001

Note that Table 37 also shows the estimated model coefficients in the Parameter Estimates table. A prediction equation for Legibility distance (Y) for Sign 3 by Log 80LI can be written using those coefficients as in Equations (7)–(9).

ANALYSIS FOR SIGN 4

Analysis with CLum_CTime 40LI

Table 38 presents the results under the initial model with CLum_CTime 40LI in place of Aspect of Profile for Sign 4.

Table 38. Output for the Initial Model with CLum_CTime 40LI for Sign 4.

Response leg_dist sign=4
Summary of Fit

RSquare	0.90643
RSquare Adj	0.89548
Root Mean Square Error	45.06315
Mean of Response	210.7358
Observations (or Sum Wgts)	106

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	32.41	1.2351	0.2746
Acuity Grp	1	1	32.09	4.8846	0.0343
legend	2	2	60.42	0.0411	0.9597
CLum_CTime 40LI	1	1	62.84	2.0430	0.1579
Age Grp*legend	2	2	60.64	0.3566	0.7015
Age Grp*CLum_CTime 40LI	1	1	62.98	3.7674	0.0567
Acuity Grp*CLum_CTime 40LI	1	1	62.51	1.8017	0.1844
legend*CLum_CTime 40LI	2	2	64.31	0.6366	0.5324

The effect of CLum_CTime 40LI on the legibility distance is positive, i.e., as CLum_CTime 40LI increases, the legibility distance increases, although the coefficient is not shown in the table. The residual plot was examined to ensure that underlying model assumptions are satisfied. Figure 10 contains the residual plot, which shows an extreme outlier (row # 439 represented by a square).

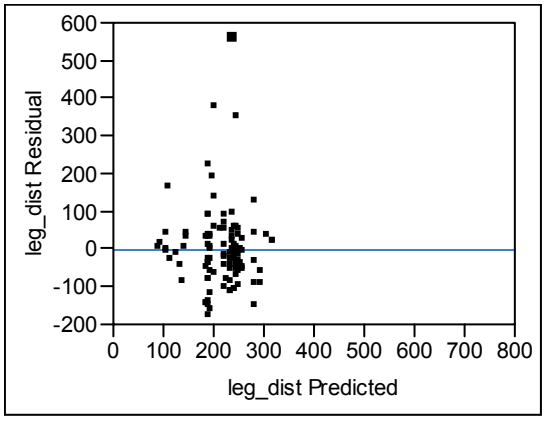


Figure 10. Residual by Predicted Plot for the Initial Model with CLum_CTime 40LI for Sign 4.

The model was refitted after removing that outlier. Table 39 contains the results.

Table 39. Output for the Initial Model with CLum_CTime 40LI for Sign 4 after Removing an Extreme Outlier.

Response leg_dist sign=4
Summary of Fit

RSquare	0.8961
RSquare Adj	0.88381
Root Mean Square Error	41.27339
Mean of Response	205.1638
Observations (or Sum Wgts)	105

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	30.77	1.7185	0.1996
Acuity Grp	1	1	30.46	5.8460	0.0218
legend	2	2	57.94	0.3001	0.7419
CLum_CTime 40LI	1	1	60.59	2.7374	0.1032
Age Grp*legend	2	2	58.16	0.5231	0.5955
Age Grp*CLum_CTime 40LI	1	1	60.75	4.3929	0.0403
Acuity Grp*CLum_CTime 40LI	1	1	60.23	1.5995	0.2108
legend*CLum_CTime 40LI	2	2	62.25	0.7595	0.4722

The residual plot contained in Figure 11 shows that the model assumptions are not seriously violated.

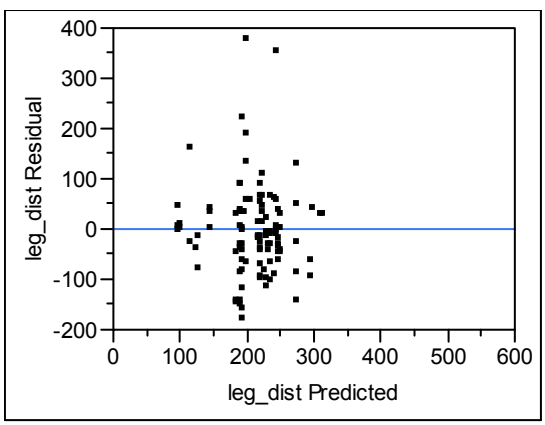


Figure 11. Residual by Predicted Plot for the Initial Model with CLum_CTime 40LI for Sign 4 after Removing an Extreme Outlier.

Figure 11 indicates that there might be two other potential outliers (observations #448 and #726 corresponding to the top two points of Figure 11), but they are not further removed from the data because they are not as extreme as the one previously removed (#439) and the removal of them changes the conclusions in an unexpected way (e.g., the effect of Legend suddenly becomes significant).

An effort has been made to select a more parsimonious model while maintaining good overall model fit. Table 40 contains the model with statistically significant (at α=0.05) effects as

well as the main effect variables that are part of two-way interaction effects. Table 40 suggests that the overall model fit stays almost the same (especially in terms of the adjusted R-square) as the initial model(s). The model in Table 40 can be selected as a final model for Sign 4 with CLum_CTime 40LI.

Table 40. Output for the Final Model with CLum_CTime 40LI for Sign 4 without an Extreme Outlier.

Response leg_dist sign=4
Summary of Fit

RSquare	0.888723
RSquare Adj	0.884271
Root Mean Square Error	40.56604
Mean of Response	205.1638
Observatios (or Sum Wgts)	105

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	204.98662	18.0238	35.08	11.37	<.0001
Age Grp[0]	-31.00967	23.23622	30.69	-1.33	0.1918
Acuity Grp[0]	53.90824	22.06011	30.78	2.44	0.0205
CLum_CTime 40LI	0.0691567	0.028288	67.32	2.44	0.0171
Age Grp[0]*(CLum_CTime 40LI-160.313)	0.0608759	0.028294	67.25	2.15	0.0350

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	30.69	1.7810	0.1918
Acuity Grp	1	1	30.78	5.9717	0.0205
CLum_CTime 40LI	1	1	67.32	5.9766	0.0171
Age Grp*CLum_CTime 40LI	1	1	67.25	4.6291	0.0350

Table 40 also shows the estimated model coefficients in the Parameter Estimates table. A prediction equation for Legibility distance (Y) for Sign 4 by CLum_CTime 40LI can be written using the coefficients in Table 40 as in Equations (1)–(3).

Analysis with Log 40LI

Table 41 presents the results under the initial model with Log 40LI in place of Aspect of Profile for Sign 4. Because the same extreme outlier as in the case of CLum_CTime 40LI was observed again, it was removed and the model was fitted to the remaining data.

Table 41. Output for the Initial Model with Log 40LI for Sign 4 without an Extreme Outlier.

Response leg_dist sign=4
Summary of Fit

RSquare	0.891606
RSquare Adj	0.878785
Root Mean Square Error	42.08773
Mean of Response	205.1638
Observations (or Sum Wgts)	105

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	30.61	2.0221	0.1651
Acuity Grp	1	1	30.46	6.3506	0.0172
legend	2	2	57.84	0.4064	0.6679
Log 40LI	1	1	60.97	3.9348	0.0518
Age Grp*legend	2	2	57.96	0.5573	0.5758
Age Grp*Log 40LI	1	1	59.93	2.9984	0.0885
Acuity Grp*Log 40LI	1	1	59.74	0.8881	0.3498
legend*Log 40LI	2	2	62.73	1.3250	0.2731

Table 42 contains the model with statistically significant (at α=0.05) effects. Because the main effect Log 40LI became significant at α=0.05 when one of the least significant terms Age Grp*legend was removed from the model, the term Log 40LI was decided to be kept in the final model. It can be seen from the table that the overall model fit stays almost the same (especially in terms of the adjusted R-square) as the initial model(s).

Table 42. Output for the Final Model with Log 40LI for Sign 4 without an Extreme Outlier.

Response leg_dist sign=4
Summary of Fit

RSquare	0.87947
RSquare Adj	0.877107
Root Mean Square Error	41.86528
Mean of Response	205.1638
Observations (or Sum Wgts)	105

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	165.37327	21.30582	75.24	7.76	<.0001
Acuity Grp[0]	34.61403	16.38365	31.95	2.11	0.0425
Log 40LI	22.685189	7.300762	69.1	3.11	0.0027

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Acuity Grp	1	1	31.95	4.4636	0.0425
Log 40LI	1	1	69.1	9.6549	0.0027

Table 42 also shows the estimated model coefficients in the Parameter Estimates table. A prediction equation for Legibility distance (Y) for Sign 4 by Log 40LI can be written using those

coefficients as in Equations (1)–(3). Note that the model in Table 42 contains two main effects Acuity Grp and Log 40LI that were observed to be significant from Table 41 but does not contain any interaction terms because none of the two-way interaction effects of Table 41 were significant.

Analysis with CLum_CTime 50LI

Table 43 presents the results under the initial model with CLum_CTime 50LI in place of Aspect of Profile for Sign 4. Because the same extreme outlier as in the case of CLum_CTime 40LI was observed again, it was removed and the model was fitted to the remaining data.

Table 43. Output for the Initial Model with CLum_CTime 50LI for Sign 4 without an Extreme Outlier.

Response leg_dist sign=4
Summary of Fit

RSquare	0.901343
RSquare Adj	0.889674
Root Mean Square Error	40.27066
Mean of Response	205.1638
Observations (or Sum Wgts)	105

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	30.98	1.5537	0.2219
Acuity Grp	1	1	30.77	5.5801	0.0247
legend	2	2	58.12	0.2991	0.7426
CLum_CTime 50LI	1	1	61.12	3.2979	0.0743
Age Grp*legend	2	2	58.28	0.4645	0.6307
Age Grp*CLum_CTime 50LI	1	1	61.36	5.3978	0.0235
Acuity Grp*CLum_CTime 50LI	1	1	60.8	2.2028	0.1429
legend*CLum_CTime 50LI	2	2	61.82	0.6695	0.5157

Table 44 contains the model with statistically significant (at α=0.05) effects as well as the main effect variables that are part of significant two-way interaction effects. Table 44 suggests that the overall model fit stays almost the same (especially in terms of the adjusted R-square) as the initial model(s). The model in Table 44 can be selected as a final model for Sign 4 with CLum_CTime 50LI.

Table 44. Output for the Final Model with CLum_CTime 50LI for Sign 4 without an Extreme Outlier.

Response leg_dist sign=4

Summary of Fit

RSquare	0.892788
RSquare Adj	0.8885
Root Mean Square Error	39.84721
Mean of Response	205.1638
Observations (or Sum Wgts)	105

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	204.03703	18.19665	35.17	11.21	<.0001
Age Grp[0]	-30.74963	23.44613	30.71	-1.31	0.1994
Acuity Grp[0]	53.911274	22.26028	30.8	2.42	0.0215
CLum_CTime 50LI	0.0502722	0.018877	67.66	2.66	0.0097
Age Grp[0]*(CLum_CTime 50LI-243.873)	0.0428826	0.018882	67.58	2.27	0.0263

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	30.71	1.7200	0.1994
Acuity Grp	1	1	30.8	5.8654	0.0215
CLum_CTime 50LI	1	1	67.66	7.0921	0.0097
Age Grp*CLum_CTime 50LI	1	1	67.58	5.1579	0.0263

Note that Table 44 also shows the estimated model coefficients in the Parameter Estimates table. A prediction equation for Legibility distance (Y) for Sign 4 by CLum_CTime 50LI can be written using those coefficients as in Equations (1)–(3).

Analysis with Log 50LI

Table 45 presents the results under the initial model with Log 50LI in place of Aspect of Profile for Sign 4. Because the same extreme outlier as in the case of CLum_CTime 40LI was observed again, it was removed and the model was fitted to the remaining data.

Table 45. Output for the Initial Model with Log 50LI for Sign 4 without an Extreme Outlier.

Response leg_dist sign=4
Summary of Fit

RSquare	0.895881
RSquare Adj	0.883565
Root Mean Square Error	41.29613
Mean of Response	205.1638
Observations (or Sum Wgts)	105

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	30.82	1.8897	0.1791
Acuity Grp	1	1	30.75	6.1792	0.0186
legend	2	2	58.03	0.3987	0.6730
Log 50LI	1	1	61.47	4.6093	0.0358
Age Grp*legend	2	2	58.12	0.5242	0.5948
Age Grp*Log 50LI	1	1	60.36	3.6530	0.0607
Acuity Grp*Log 50LI	1	1	60.21	1.0996	0.2985
legend*Log 50LI	2	2	62.22	1.2759	0.2864

Table 46 contains the model with statistically significant (at α=0.05) effects as well as the main effect variables that are part of two-way interaction effects. Table 46 suggests that the overall model fit stays almost the same (especially in terms of the adjusted R-square) as the initial model(s). The model in Table 46 can be selected as a final model for Sign 4 with Log 50LI.

Table 46. Output for the Final Model with Log 50LI for Sign 4 without Three Outliers.

Response leg_dist sign=4
Summary of Fit

RSquare	0.882426
RSquare Adj	0.88012
Root Mean Square Error	41.36976
Mean of Response	205.1638
Observations (or Sum Wgts)	105

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	156.90001	22.41478	82.5	7.00	<.0001
Acuity Grp[0]	34.863488	16.46644	31.99	2.12	0.0421
Log 50LI	24.726659	7.399219	69.48	3.34	0.0013

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Acuity Grp	1	1	31.99	4.4827	0.0421
Log 50LI	1	1	69.48	11.1676	0.0013

Table 46 also shows the estimated model coefficients in the Parameter Estimates table. A prediction equation for Legibility distance (Y) for Sign 4 by Log 50LI can be written using those coefficients as in Equations (1)–(3). Note that the model in Table 46 contains two main effects

Acuity Grp and Log 50LI that were observed to be significant from Table 45 but does not contain any interaction terms because none of the two-way interaction effects of Table 45 were significant.

Analysis with CLum_CTime 80LI

Table 47 presents the results under the initial model with CLum_CTime 80LI in place of Aspect of Profile for Sign 4 fitted to the dataset without an extreme outlier identified earlier (#439).

Table 47. Output for the Initial Model with CLum_CTime 80LI for Sign 4 without an Outlier.

Response leg_dist sign=4
Summary of Fit

RSquare	0.904407
RSquare Adj	0.893101
Root Mean Square Error	39.67045
Mean of Response	205.1638
Observations (or Sum Wgts)	105

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	31.08	1.4552	0.2368
Acuity Grp	1	1	30.95	5.4138	0.0267
legend	2	2	58.19	0.3153	0.7308
CLum_CTime 80LI	1	1	61.48	3.7256	0.0582
Age Grp*legend	2	2	58.31	0.4221	0.6576
Age Grp*CLum_CTime 80LI	1	1	61.7	5.9150	0.0179
Acuity Grp*CLum_CTime 80LI	1	1	61.12	2.6135	0.1111
legend*CLum_CTime 80LI	2	2	61.55	0.6164	0.5432

Table 48 contains the final model selected, which suggests that the overall model fit stays almost the same (especially in terms of the adjusted R-square) as the initial model(s).

Table 48. Output for the Final Model with CLum_CTime 80LI for Sign 4 without an Extreme Outlier.

Response leg_dist sign=4
Summary of Fit

RSquare	0.895077
RSquare Adj	0.89088
Root Mean Square Error	39.43667
Mean of Response	205.1638
Observations (or Sum Wgts)	105

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	203.00409	18.36629	35.53	11.05	<.0001
Age Grp[0]	-30.57164	23.60045	30.71	-1.30	0.2048
Acuity Grp[0]	53.95329	22.40776	30.81	2.41	0.0222
CLum_CTime 80LI	0.0373036	0.013348	67.94	2.79	0.0067
Age Grp[0]*(CLum_CTime 80LI-360.77)	0.0305627	0.013352	67.85	2.29	0.0252

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	30.71	1.6780	0.2048
Acuity Grp	1	1	30.81	5.7975	0.0222
CLum_CTime 80LI	1	1	67.94	7.8100	0.0067
Age Grp*CLum_CTime 80LI	1	1	67.85	5.2397	0.0252

Note that Table 48 also shows the estimated model coefficients in the Parameter Estimates table. A prediction equation for Legibility distance (Y) for Sign 4 by CLum_CTime 80LI can be written using those coefficients as in Equations (1)–(3).

Analysis with Log 80LI

Table 49 presents the results under the initial model with Log 80LI in place of Aspect of Profile for Sign 4 fitted to the dataset without an extreme outlier identified earlier (#439).

Table 49. Output for the Initial Model with Log 80LI for Sign 4 without an Extreme Outlier.

Response leg_dist sign=4
Summary of Fit

RSquare	0.898585
RSquare Adj	0.88659
Root Mean Square Error	40.79008
Mean of Response	205.1638
Observations (or Sum Wgts)	105

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	30.95	1.7689	0.1932
Acuity Grp	1	1	30.93	5.9920	0.0202
legend	2	2	58.14	0.3881	0.6801
Age Grp*legend	2	2	58.2	0.4814	0.6203
Log 80LI	1	1	61.78	4.9538	0.0297
Age Grp*Log 80LI	1	1	60.82	4.1529	0.0459
Acuity Grp*Log 80LI	1	1	60.67	1.3186	0.2553
legend*Log 80LI	2	2	61.85	1.1174	0.3336

Table 50 contains the model with statistically significant (at α=0.05) effects as well as the main effect variables that are part of two-way interaction effects.

Table 50. Output for the Second Model with Log 80LI for Sign 4 without an Extreme Outlier.

Response leg_dist sign=4
Summary of Fit

RSquare	0.890289
RSquare Adj	0.8859
Root Mean Square Error	40.2798
Mean of Response	205.1638
Observations (or Sum Wgts)	105

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	162.70046	25.72373	90.82	6.32	<.0001
Age Grp[0]	-30.6497	23.16188	30.74	-1.32	0.1955
Acuity Grp[0]	53.752086	21.99463	30.85	2.44	0.0204
Log 80LI	23.617101	8.360513	68.45	2.82	0.0062
Age Grp[0]*(Log 80LI-2.26378)	16.251118	8.364029	68.31	1.94	0.0561

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	30.74	1.7511	0.1955
Acuity Grp	1	1	30.85	5.9725	0.0204
Log 80LI	1	1	68.45	7.9797	0.0062
Age Grp*Log 80LI	1	1	68.31	3.7752	0.0561

Table 50 shows that the interaction effect Age Grp*Log 80LI becomes insignificant at α=0.05 when other insignificant terms of Table 49 are removed from the model. The reduced model without insignificant terms Age Grp*Log 80LI and Age Grp is fitted again to the Sign 4 data.

Table 51 contains a final model for Sign 4 with Log 80LI. It can be seen from the table that the overall model fit for the model in Table 51 stays almost the same (especially in terms of the adjusted R-square) as the models in Table 49 and Table 50.

Table 51. Output for the Final Model with Log 80LI for Sign 4 without an Extreme Outlier.

Response leg_dist sign=4
Summary of Fit

RSquare	0.884493
RSquare Adj	0.882228
Root Mean Square Error	41.0214
Mean of Response	205.1638
Observations (or Sum Wgts)	105

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	143.53896	24.78165	94.26	5.79	<.0001
Acuity Grp[0]	35.136973	16.56062	32	2.12	0.0417
Log 80LI	28.370895	8.146639	69.73	3.48	0.0009

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Acuity Grp	1	1	32	4.5017	0.0417
Log 80LI	1	1	69.73	12.1280	0.0009

Note that Table 51 also shows the estimated model coefficients in the Parameter Estimates table. A prediction equation for Legibility distance (Y) for Sign 4 by Log 80LI can be written using those coefficients as in Equations (1)–(3).

ANALYSIS OF LEGIBILITY DATA WITHOUT ACUITY

In the current analyses, the model with Legibility Distance as a response variable, Age Group, Legend, and Aspect of Profile (each of six variables, CLum_Ctime 40LI, CLum_CTime50LI, Log 40LI, LOG(CLum)_Ctime 40LI, Log 50LI, and LOG(CLum)_Ctime 50LI) as main effects and Age Group* Legend, Legend* Aspect of Profile, and Age Group* Aspect of Profile, as two-way interactions were used as an initial model for all of the four signs. Then the insignificant effects were removed from the initial model one at a time, and only statistically significant effects (at α=0.05) as well as the main effect variables that are part of significant two-way interaction effects were retained in the final model. The overall model fit (R^2 and adjusted R^2) did not change significantly between the initial model and the final model.

Also, the same set of outliers were identified as in the previous analysis (although the current analysis does not contain Acuity, and the variables LOG(CLum)_Ctime 40LI and LOG(CLum)_Ctime 50LI are newly added): for Sign 1, 6 outliers (observation # 709, 712, 727, 730, 736, 739) from Subject 21 and 1 outlier (observation # 1116) from Subject 32 were observed, and for Sign 4, an extreme outlier (observation # 439) from Subject 13 was observed

again. Those outliers had been removed from the data before more parsimonious models were explored. In this report, only the results from the final models are presented.

Analysis for Sign 1

Table 52 shows that there is a statistically significant interaction effect between Age Group (0: ≤ 55 years, 1: > 55 years) and CLum_CTime 40LI. The estimated model coefficients in the Parameter Estimates table suggest that the rate of increase (slope for CLum_CTime 40LI) of legibility distance (as CLum_CTime 40LI increases) is larger for young drivers than for old drivers. Tables 53 through 75 show additional analysis results by aspect of profile.

Table 52. Output for the Final Model with CLum_CTime 40LI for Sign 1 without Seven Outliers.

Response leg_dist sign=1
Summary of Fit

RSquare	0.715846
RSquare Adj	0.713796
Root Mean Square Error	49.8744
Mean of Response	222.0986
Observations (or Sum Wgts)	420

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	190.13097	11.57328	37.51	16.43	<.0001
Age Grp[0]	37.358516	11.28499	33.91	3.31	0.0022
CLum_CTime 40LI	0.2511844	0.031074	381.9	8.08	<.0001
Age Grp[0]*(CLum_CTime 40LI-82.1944)	0.0943261	0.031074	381.9	3.04	0.0026

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	33.91	10.9591	0.0022
CLum_CTime 40LI	1	1	381.9	65.3398	<.0001
Age Grp*CLum_CTime 40LI	1	1	381.9	9.2142	0.0026

Table 53. Output for the Final Model with CLum_CTime 50LI for Sign 1 without Seven Outliers.

Response leg_dist sign=1
Summary of Fit

RSquare	0.728869
RSquare Adj	0.726914
Root Mean Square Error	48.72321
Mean of Response	222.0986
Observations (or Sum Wgts)	420

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	188.07811	11.5645	37.43	16.26	<.0001
Age Grp[0]	37.386843	11.28239	33.92	3.31	0.0022
CLum_CTime 50LI	0.1893328	0.021042	381.9	9.00	<.0001
Age Grp[0]*(CLum_CTime 50LI-119.899)	0.0691744	0.021042	381.9	3.29	0.0011

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	33.92	10.9808	0.0022
CLum_CTime 50LI	1	1	381.9	80.9624	<.0001
Age Grp*CLum_CTime 50LI	1	1	381.9	10.8074	0.0011

Table 54. Output for the Final Model with Log 40LI for Sign 1 without Seven Outliers.

Response leg_dist
Summary of Fit

RSquare	0.747499
RSquare Adj	0.745678
Root Mean Square Error	47.02681
Mean of Response	222.0986
Observations (or Sum Wgts)	420

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	146.54643	12.8173	56.03	11.43	<.0001
Age Grp[0]	37.357689	11.28526	33.92	3.31	0.0022
Log 40LI	40.586933	3.832442	381.9	10.59	<.0001
Age Grp[0]*(Log 40LI-1.58273)	11.488436	3.832442	381.9	3.00	0.0029

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	33.92	10.9581	0.0022
Log 40LI	1	1	381.9	112.1557	<.0001
Age Grp*Log 40LI	1	1	381.9	8.9861	0.0029

Table 55. Output for the Final Model with LOG(CLum)_Ctime 40LI for Sign 1 without Seven Outliers.

Response leg_dist
Summary of Fit

RSquare	0.74576
RSquare Adj	0.743927
Root Mean Square Error	47.18778
Mean of Response	222.0986
Observations (or Sum Wgts)	420

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	168.18057	12.00433	43.33	14.01	<.0001
Age Grp[0]	37.348464	11.28723	33.92	3.31	0.0022
LOG(CLum)_Ctime 40LI	12.256521	1.17277	381.9	10.45	<.0001
Age Grp[0]*(LOG(CLum)_Ctime 40LI-3.4764)	3.5150547	1.17277	381.9	3.00	0.0029

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	33.92	10.9489	0.0022
LOG(CLum)_Ctime 40LI	1	1	381.9	109.2216	<.0001
Age Grp*LOG(CLum)_Ctime 40LI	1	1	381.9	8.9833	0.0029

Table 56. Output for the Final Model with Log 50LI for Sign 1 without Seven Outliers.

Response leg_dist
Summary of Fit

RSquare	0.76025
RSquare Adj	0.758521
Root Mean Square Error	45.82872
Mean of Response	222.0986
Observations (or Sum Wgts)	420

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	135.28386	13.05388	60.23	10.36	<.0001
Age Grp[0]	37.385067	11.28054	33.92	3.31	0.0022
Log 50LI	43.084677	3.741111	381.9	11.52	<.0001
Age Grp[0]*(Log 50LI-1.75227)	12.004333	3.741111	381.9	3.21	0.0014

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	33.92	10.9834	0.0022
Log 50LI	1	1	381.9	132.6309	<.0001
Age Grp*Log 50LI	1	1	381.9	10.2962	0.0014

Table 57. Output for the Final Model with LOG(CLum)_Ctime 50LI for Sign 1 without Seven Outliers.

Response leg_dist
Summary of Fit

RSquare	0.760638
RSquare Adj	0.758912
Root Mean Square Error	45.79187
Mean of Response	222.0986
Observations (or Sum Wgts)	420

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	164.98716	11.96866	42.89	13.78	<.0001
Age Grp[0]	37.37268	11.28377	33.92	3.31	0.0022
LOG(CLum)_Ctime 50LI	9.0903298	0.789598	381.9	11.51	<.0001
Age Grp[0]*(LOG(CLum)_Ctime 50LI-5.03863)	2.5878283	0.789598	381.9	3.28	0.0011

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	33.92	10.9698	0.0022
LOG(CLum)_Ctime 50LI	1	1	381.9	132.5401	<.0001
Age Grp*LOG(CLum)_Ctime 50LI	1	1	381.9	10.7413	0.0011

Analysis for Sign 2

Table 58. Output for the Final Model with CLum_CTime 40LI for Sign 2.

Response leg_dist sign=2
Summary of Fit

RSquare	0.762003
RSquare Adj	0.760323
Root Mean Square Error	78.53749
Mean of Response	408.7219
Observations (or Sum Wgts)	429

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	353.28934	20.07774	36.63	17.60	<.0001
Age Grp[0]	76.567164	19.70418	33.98	3.89	0.0004
CLum_CTime 40LI	0.2153733	0.0279	391	7.72	<.0001
Age Grp[0]*(CLum_CTime 40LI-137.675)	0.0758228	0.0279	391	2.72	0.0069

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	33.98	15.0997	0.0004
CLum_CTime 40LI	1	1	391	59.5923	<.0001
Age Grp*CLum_CTime 40LI	1	1	391	7.3859	0.0069

Table 59. Output for the Final Model with Clum_Ctime 50LI for Sign 2.

Response leg_dist sign=2
Summary of Fit

Rsquare	0.773079
Rsquare Adj	0.771477
Root Mean Square Error	76.69467
Mean of Response	408.7219
Observations (or Sum Wgts)	429

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	350.5929	20.07297	36.59	17.47	<.0001
Age Grp[0]	76.549846	19.70557	33.98	3.88	0.0005
Clum_Ctime 50LI	0.1559438	0.018373	391	8.49	<.0001
Age Grp[0]*(Clum_Ctime 50LI-207.427)	0.060781	0.018373	391	3.31	0.0010

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	33.98	15.0908	0.0005
Clum_Ctime 50LI	1	1	391	72.0425	<.0001
Age Grp*Clum_Ctime 50LI	1	1	391	10.9443	0.0010

Table 60. Output for the Final Model with Log 40LI for Sign 2.

Response leg_dist sign=2
Summary of Fit

RSquare	0.780317
RSquare Adj	0.778766
Root Mean Square Error	75.46575
Mean of Response	408.7219
Observations (or Sum Wgts)	429

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	279.81992	22.4733	56.97	12.45	<.0001
Age Grp[0]	76.708764	19.71181	33.99	3.89	0.0004
Log 40LI	57.481319	6.005436	391	9.57	<.0001
Age Grp[0]*(Log 40LI-1.79375)	16.461786	6.005436	391	2.74	0.0064

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	33.99	15.1439	0.0004
Log 40LI	1	1	391	91.6145	<.0001
Age Grp*Log 40LI	1	1	391	7.5139	0.0064

Table 61. Output for the Final Model with LOG(CLum)_Ctime 40LI for Sign 2.

Response leg_dist
Summary of Fit

RSquare	0.776195
RSquare Adj	0.774615
Root Mean Square Error	76.16808
Mean of Response	408.7219
Observations (or Sum Wgts)	429

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	324.46584	20.69873	41.31	15.68	<.0001
Age Grp[0]	76.701732	19.70856	33.99	3.89	0.0004
LOG(CLum)_Ctime 40LI	10.451907	1.127171	391	9.27	<.0001
Age Grp[0]*(LOG(CLum)_Ctime 40LI-5.59328)	2.8688975	1.127171	391	2.55	0.0113

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	33.99	15.1461	0.0004
LOG(CLum)_Ctime 40LI	1	1	391	85.9828	<.0001
Age Grp*LOG(CLum)_Ctime 40LI	1	1	391	6.4781	0.0113

Table 62. Output for the Final Model with Log 50LI for Sign 2.

Response leg_dist
Summary of Fit

RSquare	0.791553
RSquare Adj	0.790082
Root Mean Square Error	73.51671
Mean of Response	408.7219
Observations (or Sum Wgts)	429

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	262.24452	22.90335	61.26	11.45	<.0001
Age Grp[0]	76.696317	19.7145	33.99	3.89	0.0004
Log 50LI	60.908831	5.873786	391	10.37	<.0001
Age Grp[0]*(Log 50LI-1.98143)	19.421835	5.873786	391	3.31	0.0010

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	33.99	15.1348	0.0004
Log 50LI	1	1	391	107.5287	<.0001
Age Grp*Log 50LI	1	1	391	10.9331	0.0010

Table 63. Output for the Final Model with LOG(CLum)_Ctime 50LI for Sign 2.

Response leg_dist
Summary of Fit

RSquare	0.791413
RSquare Adj	0.78994
Root Mean Square Error	73.54138
Mean of Response	408.7219
Observations (or Sum Wgts)	429

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	318.58792	20.66819	41.06	15.41	<.0001
Age Grp[0]	76.6849	19.7099	33.99	3.89	0.0004
LOG(CLum)_Ctime 50LI	7.6658905	0.738932	391	10.37	<.0001
Age Grp[0]*(LOG(CLum)_Ctime 50LI-8.39349)	2.4237807	0.738932	391	3.28	0.0011

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	33.99	15.1374	0.0004
LOG(CLum)_Ctime 50LI	1	1	391	107.6259	<.0001
Age Grp*LOG(CLum)_Ctime 50LI	1	1	391	10.7592	0.0011

Analysis for Sign 3

Table 64. Output for the Final Model with CLum_CTime 40LI for Sign 3 without Seven Outliers.

Response leg_dist sign=3
Summary of Fit

RSquare	0.795645
RSquare Adj	0.793667
Root Mean Square Error	75.95521
Mean of Response	401.8678
Observations (or Sum Wgts)	314

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	349.88867	22.09467	36.96	15.84	<.0001
Age Grp[0]	64.969821	21.64113	34.03	3.00	0.0050
CLum_CTime 40LI	0.3572855	0.052297	276.5	6.83	<.0001
Age Grp[0]*(CLum_CTime 40LI-84.8283)	0.1755324	0.052297	276.5	3.36	0.0009

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	34.03	9.0129	0.0050
CLum_CTime 40LI	1	1	276.5	46.6747	<.0001
Age Grp*CLum_CTime 40LI	1	1	276.5	11.2659	0.0009

Table 65. Output for the Final Model with CLum_CTime 50LI for Sign 3.

Response leg_dist sign=3
Summary of Fit

RSquare	0.80137
RSquare Adj	0.799448
Root Mean Square Error	74.8896
Mean of Response	401.8678
Observations (or Sum Wgts)	314

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	348.28211	22.10667	36.94	15.75	<.0001
Age Grp[0]	64.95598	21.65692	34.03	3.00	0.0050
CLum_CTime 50LI	0.2579542	0.035736	276.5	7.22	<.0001
Age Grp[0]*(CLum_CTime 50LI-123.692)	0.1298388	0.035736	276.5	3.63	0.0003

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	34.03	8.9959	0.0050
CLum_CTime 50LI	1	1	276.5	52.1043	<.0001
Age Grp*CLum_CTime 50LI	1	1	276.5	13.2007	0.0003

Table 66. Output for the Final Model with Log 40LI for Sign 3.

Response leg_dist
Summary of Fit

RSquare	0.81462
RSquare Adj	0.812826
Root Mean Square Error	72.36232
Mean of Response	401.8678
Observations (or Sum Wgts)	314

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	288.86355	24.26679	52.69	11.90	<.0001
Age Grp[0]	64.94261	21.71044	34.03	2.99	0.0051
Log 40LI	57.341412	6.801142	276.4	8.43	<.0001
Age Grp[0]*(Log 40LI-1.59292)	24.468538	6.801142	276.4	3.60	0.0004

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	34.03	8.9479	0.0051
Log 40LI	1	1	276.4	71.0842	<.0001
Age Grp*Log 40LI	1	1	276.4	12.9435	0.0004

Table 67. Output for the Final Model with LOG(CLum)_Ctime 40LI for Sign 3.

Response leg_dist
Summary of Fit

RSquare	0.809488
RSquare Adj	0.807645
Root Mean Square Error	73.35157
Mean of Response	401.8678
Observations (or Sum Wgts)	314

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	322.29503	22.85553	41.96	14.10	<.0001
Age Grp[0]	64.946638	21.68007	34.03	3.00	0.0051
LOG(CLum)_Ctime 40LI	8.7972635	1.097859	276.4	8.01	<.0001
Age Grp[0]*(LOG(CLum)_Ctime 40LI-6.58324)	3.8152218	1.097859	276.4	3.48	0.0006

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	34.03	8.9741	0.0051
LOG(CLum)_Ctime 40LI	1	1	276.4	64.2099	<.0001
Age Grp*LOG(CLum)_Ctime 40LI	1	1	276.4	12.0767	0.0006

Table 68. Output for the Final Model with Log 50LI for Sign 3.

Response leg_dist
Summary of Fit

RSquare	0.820175
RSquare Adj	0.818435
Root Mean Square Error	71.27545
Mean of Response	401.8678
Observations (or Sum Wgts)	314

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	275.66411	24.7578	56.61	11.13	<.0001
Age Grp[0]	64.927025	21.73784	34.03	2.99	0.0052
Log 50LI	59.315013	6.720055	276.4	8.83	<.0001
Age Grp[0]*(Log 50LI-1.76233)	25.735798	6.720055	276.4	3.83	0.0002

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	34.03	8.9211	0.0052
Log 50LI	1	1	276.4	77.9083	<.0001
Age Grp*Log 50LI	1	1	276.4	14.6666	0.0002

Table 69. Output for the Final Model with LOG(CLum)_Ctime 50LI for Sign 3.

Response leg_dist
Summary of Fit

RSquare	0.820365
RSquare Adj	0.818627
Root Mean Square Error	71.23752
Mean of Response	401.8678
Observations (or Sum Wgts)	314

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	317.87379	22.84778	41.7	13.91	<.0001
Age Grp[0]	64.917273	21.70681	34.03	2.99	0.0051
LOG(CLum)_Ctime 50LI	6.2591406	0.715457	276.4	8.75	<.0001
Age Grp[0]*(LOG(CLum)_Ctime 50LI-9.95717)	2.8526612	0.715457	276.4	3.99	<.0001

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	34.03	8.9439	0.0051
LOG(CLum)_Ctime 50LI	1	1	276.4	76.5354	<.0001
Age Grp*LOG(CLum)_Ctime 50LI	1	1	276.4	15.8977	<.0001

Analysis for Sign 4

Table 70. Output for the Final Model with CLum_CTime 40LI for Sign 4 without an Extreme Outlier.

Response leg_dist sign=4
Summary of Fit

RSquare	0.889299
RSquare Adj	0.886011
Root Mean Square Error	40.5257
Mean of Response	205.1638
Observations (or Sum Wgts)	105

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	198.29834	19.03106	36.03	10.42	<.0001
CLum_CTime 40LI	0.0691014	0.028284	67.24	2.44	0.0172
Age Grp[0]	7.2136976	18.47757	32.03	0.39	0.6988
Age Grp[0]*(CLum_CTime 40LI-160.313)	0.0621842	0.028284	67.24	2.20	0.0314

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
CLum_CTime 40LI	1	1	67.24	5.9688	0.0172
Age Grp	1	1	32.03	0.1524	0.6988
Age Grp*CLum_CTime 40LI	1	1	67.24	4.8336	0.0314

Table 71. Output for the Final Model with CLum_CTime 50LI for Sign 4 without an Extreme Outlier.

Response leg_dist sign=4
Summary of Fit

RSquare	0.893313
RSquare Adj	0.890144
Root Mean Square Error	39.80873
Mean of Response	205.1638
Observations (or Sum Wgts)	105

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	197.35138	19.18942	36.14	10.28	<.0001
Age Grp[0]	7.4740678	18.61726	32.04	0.40	0.6907
CLum_CTime 50LI	0.0502372	0.018877	67.56	2.66	0.0097
Age Grp[0]*(CLum_CTime 50LI-243.873)	0.0439063	0.018877	67.56	2.33	0.0230

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	32.04	0.1612	0.6907
CLum_CTime 50LI	1	1	67.56	7.0828	0.0097
Age Grp*CLum_CTime 50LI	1	1	67.56	5.4102	0.0230

Table 72. Output for the Final Model with Log 40LI for Sign 4 without an Extreme Outlier.

Response leg_dist
Summary of Fit

RSquare	0.879686
RSquare Adj	0.878518
Root Mean Square Error	41.86992
Mean of Response	205.1638
Observations (or Sum Wgts)	105

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	169.22528	21.84874	74.51	7.75	<.0001
Log 40LI	22.668572	7.307193	68.78	3.10	0.0028

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Log 40LI	1	1	68.78	9.6238	0.0028

Table 73. Output for the Final Model with LOG(CLum)_Ctime 40LI for Sign 4 without an Extreme Outlier.

Response leg_dist
Summary of Fit

RSquare	0.880255
RSquare Adj	0.879092
Root Mean Square Error	41.77496
Mean of Response	205.1638
Observations (or Sum Wgts)	105

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	186.89919	18.80391	47.34	9.94	<.0001
LOG(CLum)_Ctime 40LI	7.0208995	2.232843	68.84	3.14	0.0025

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
LOG(CLum)_Ctime 40LI	1	1	68.84	9.8871	0.0025

Table 74. Output for the Final Model with Log 50LI for Sign 4 without an Extreme Outlier.

Response leg_dist
Summary of Fit

RSquare	0.882632
RSquare Adj	0.881493
Root Mean Square Error	41.37404
Mean of Response	205.1638
Observations (or Sum Wgts)	105

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	160.83204	22.93737	81.72	7.01	<.0001
Log 50LI	24.686878	7.406284	69.13	3.33	0.0014

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Log 50LI	1	1	69.13	11.1104	0.0014

Table 75. Output for the Final Model with LOG(CLum)_Ctime 50LI for Sign 4 without an Extreme Outlier.

Response leg_dist

Summary of Fit

RSquare	0.889046
RSquare Adj	0.885751
Root Mean Square Error	40.55936
Mean of Response	205.1638
Observations (or Sum Wgts)	105

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	187.89901	20.06494	45.24	9.36	<.0001
Age Grp[0]	7.2865656	18.32938	32.04	0.40	0.6936
LOG(CLum)_Ctime 50LI	4.2431072	1.600596	68.02	2.65	0.0100
Age Grp[0]*(LOG(CLum)_Ctime 50LI-5.06326)	3.2512871	1.600596	68.02	2.03	0.0461

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age Grp	1	1	32.04	0.1580	0.6936
LOG(CLum)_Ctime 50LI	1	1	68.02	7.0276	0.0100
Age Grp*LOG(CLum)_Ctime 50LI	1	1	68.02	4.1262	0.0461

CHAPTER 3: STATISTICAL RESULTS OF LEGIBILITY DATA FROM PHASE III

INTRODUCTION

In this chapter, detailed statistical testing results are presented for the legibility data obtained from Phase III of the study. These analyses were aimed at determining the effect of sign reflective levels on legibility distance. The dependent variable of the analysis is Legibility Distance (measured in feet) and the main factor of interest is Reflective Level (Low, Medium, High). Other variables considered in the analysis are driver's Age (Old: ≥ 55 years, Young: < 55 years), Reflectivity Type (II: Internally Illuminated, RS: Reflective Sheeting), Course Type (Closed, Open), Course Setting (Rural, Urban), Letter Height (6, 7, 8, 10), and Headlight Beam Type (Low, High). Although there were some additional variables such as Gender, Ethnicity, Employment, and Education in the original data, those variables turned out to be insignificant when included in the models explored and are not considered here.

There are four different sign types: Warning, Regulatory, Guide, and Street Name. Analyses are conducted separately by sign type. For each sign type, the data are analyzed utilizing the split-plot design with Subject (driver) as a whole-plot and each treatment combination as a split-plot. The variable Age is treated as a whole plot factor while some of the remaining variables mentioned above serve as split-plot factors. It needs to be noted that for these data, not all conditions were replicated throughout the study, and except for Age and Reflective Level, the levels of other factors/variables are different for different sign types (i.e., factor levels are nested within each sign type). Table 76 shows the levels of factors/variables for each sign type.

Table 76. Levels of Factors/Variables for Each Sign Type.

Sign Type	Warning	Regulatory	Guide	Street Name
Reflective Level	Low, Medium, High	Low, Medium, High	Low, Medium, High	Low, Medium, High
Age	Old, Young	Old, Young	Old, Young	Old, Young
Reflectivity Type	II (Low or High, Closed, Rural), RS	II (Low or High), RS	RS	RS
Course Type	Closed (Rural), Open (RS)	Closed (Rural), Open (RS)	Open	Open
Course Setting	Rural, Urban (Open)	Rural	Rural, Urban	Rural, Urban
Letter Height	7	7, 10	8	6
Headlight Beam Type	Low	Low (7), High (10, RS, Closed, Low or Medium)	Low	Low

Note: A(B) represents that level A exists only for level B (of another factor).

ANALYSIS FOR WARNING SIGNS

Analysis by Reflectivity Type

For warning signs, Reflectivity Type II (Internally Illuminated) is present only for Course Type=Closed and Course Setting=Rural, and for Reflective Level = Low or High. To prevent potential confounding between Reflectivity Type and other factors, data are analyzed separately for each level of Reflectivity Type, rather than just ignoring Reflectivity Type in the analysis.

Analysis for Internally Illuminated Warning Signs

A split-plot model with Age and Reflective Level as main effects, Age*Reflective Level as a two-way interaction, and Driver nested within Age as a random effect is used as an initial model for internally illuminated warning signs. Table 77 contains the results obtained by the initial model. It can be observed from the Fixed Effect Tests table that the effect of Reflective Level is significant at α=0.05. Effect Details table for Reflective Level shows the least squares means for legibility distance for each level of Reflective Level, suggesting that a High reflective level leads to longer legibility distance.

Table 77. Output for the Initial Model for Internally Illuminated Warning Signs.

Response Legibility Distance (ft) Reflectivity Type=II

Summary of Fit

RSquare	0.909541
RSquare Adj	0.902756
Root Mean Square Error	39.43088
Mean of Response	223.2039
Observations (or Sum Wgts)	44

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Reflective Level	1	1	19.55	4.8508	0.0398
Age	1	1	21.13	2.3261	0.1420
Age*Reflective Level	1	1	19.55	0.0883	0.7695

Effect Details

Reflective Level

Least Squares Means Table

Level	Least Sq Mean	Std Error
Low	205.87769	19.217647
High	232.89262	19.217647

Age

Least Squares Means Table

Level	Least Sq Mean	Std Error
Old	191.60759	28.338554
Young	247.16272	22.885518

Age*Reflective Level

Least Squares Means Table

Level	Least Sq Mean	Std Error
Old,Low	179.92241	29.823667
Old,High	203.29278	29.823667
Young,Low	231.83298	24.245015
Young,High	262.49246	24.245015

Table 78 contains the reduced model with Reflective Level (which was statistically significant at α=0.05 in the initial model) as a main effect and Drivers as random blocks, which leads to basically the same conclusion on the effect of Reflective Level as above.

Table 78. Output for the Reduced Model for Internally Illuminated Warning Signs.

Response Legibility Distance (ft) Reflectivity Type=II

Summary of Fit

RSquare	0.909942
RSquare Adj	0.907798
Root Mean Square Error	38.57236
Mean of Response	223.2039
Observations (or Sum Wgts)	44

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Reflective Level	1	1	20.52	5.3840	0.0307

Effect Details

Reflective Level

Least Squares Means Table

Level	Least Sq Mean	Std Error
Low	211.50967	19.251607
High	239.05053	19.251607

Analysis for Reflective Sheeting Warning Signs

For Reflectivity Type RS (Reflective Sheeting), there are two levels for each of Course Type and Course Setting. To get a better understanding of the effects of Course Type and Course Setting as well as their joint effect on legibility distance, factors 'Course Type' and 'Course Setting' are combined into a new factor 'Course' with three levels (Closed-Rural, Open-Rural, Open-Urban) for Reflective Sheeting Warning signs. A split-plot model with Age, Reflective Level, and Course as main effects, Age*Reflective Level and Course *Reflective Level as two-way interactions, and Driver nested within Age as a random effect is used as an initial model. Table 79 contains the results under the initial model, which shows that Reflective Level, Course, and Age were significant at α=0.05 (see Fixed Effect Tests table). It can be observed from the Effect Details table that a higher reflective level, Closed course, and/or Young age group corresponds to longer legibility distance. Figure 12 contains the plots of least squares means, which illustrates the effects of each factor. Note that the interaction plots (Figures 12d and 12e) are information purposes only (interactions were not statistically significant).

Table 79. Output for the Initial Model for Reflective Sheeting Warning Signs.

Response Legibility Distance (ft) Reflectivity Type=RS
Summary of Fit

RSquare	0.777223
RSquare Adj	0.75697
Root Mean Square Error	52.24978
Mean of Response	215.2654
Observations (or Sum Wgts)	133

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Reflective Level	2	2	100.2	3.4159	0.0367
Course	2	2	99.85	12.8530	<.0001
Age	1	1	20.49	7.1768	0.0142
Reflective Level*Course	4	4	102.4	1.0283	0.3964
Age*Reflective Level	2	2	99.93	1.0907	0.3399

Effect Details

Reflective Level
Least Squares Means Table

Level	Least Sq Mean	Std Error
Low	178.35461	17.755516
Medium	202.52642	17.821863
High	210.04256	17.782204

Course
Least Squares Means Table

Level	Least Sq Mean	Std Error
Closed-Rural	226.62970	16.653618
Open-Rural	176.76648	17.345381
Open-Urban	187.52741	19.060651

Age
Least Squares Means Table

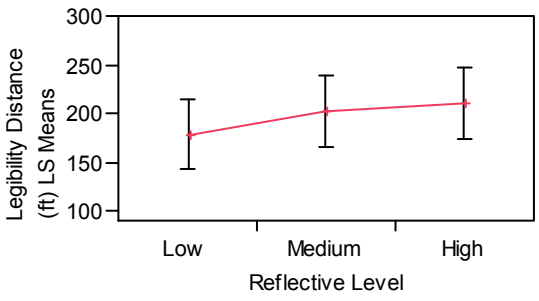
Level	Least Sq Mean	Std Error
Old	153.96643	25.093399
Young	239.98262	20.241365

Reflective Level*Course
Least Squares Means Table

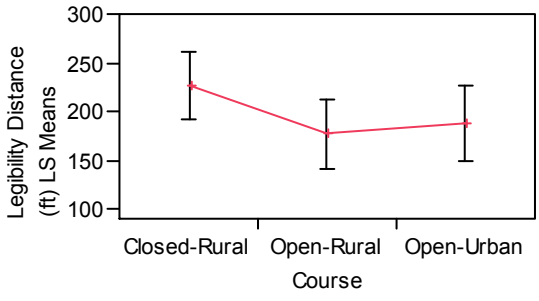
Level	Least Sq Mean	Std Error
Low,Closed-Rural	208.75494	18.900326
Low,Open-Rural	169.05650	20.806286
Low,Open-Urban	157.25237	26.123883
Medium,Closed-Rural	230.84389	19.497096
Medium,Open-Rural	193.43780	21.095366
Medium,Open-Urban	183.29756	25.389502
High,Closed-Rural	240.29026	18.888694
High,Open-Rural	167.80513	21.253938
High,Open-Urban	222.03229	26.082801

Age*Reflective Level
Least Squares Means Table

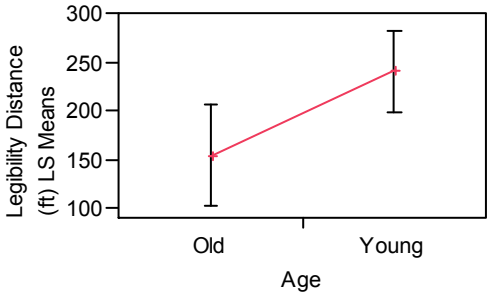
Level	Least Sq Mean	Std Error
Old,Low	133.90253	27.013726
Old,Medium	151.66036	27.906935
Old,High	176.33640	27.073468
Young,Low	222.80668	22.307561
Young,Medium	253.39247	21.815570
Young,High	243.74871	22.403431



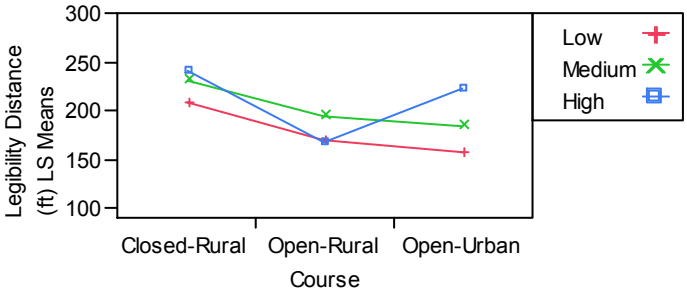
(a) LS Means Plot for Reflective Level



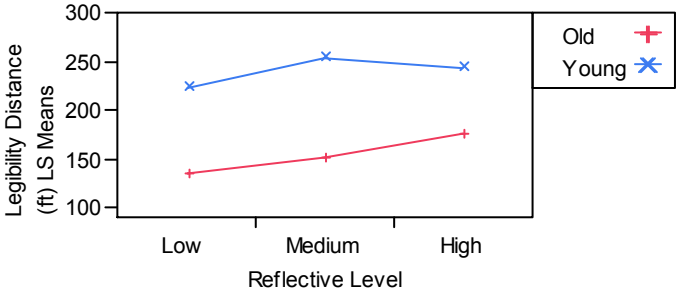
(b) LS Means Plot for Course



(c) LS Means Plot for Age



(d) LS Means Plot for Reflective Level*Course



(e) LS Means Plot for Age*Reflective Level

Figure 12. Least Squares Means Plots of Factor Effects for Reflective Sheeting Warning Signs.

Table 80 contains the reduced model with Reflective Level, Course, and Age (which were statistically significant at α=0.05 in the initial model) as main effects and Drivers (nested within Age) as random effects, which leads to basically the same conclusions on the effects of Reflective Level, Course, and Age as above. Multiple comparison tests (Fisher's Protected LSD) indicate that for Reflective Level, High and Medium are significantly different from Low although High and Medium are not significantly different. For Course, Closed-Rural is

significantly different from Open-Rural and Open-Urban although Open-Rural and Open-Urban are not significantly different.

Table 80. Output for the Reduced Model for Reflective Sheeting Warning Signs.

Response Legibility Distance (ft) Reflectivity Type=RS

Summary of Fit

RSquare	0.760281
RSquare Adj	0.750843
Root Mean Square Error	52.65369
Mean of Response	215.2654
Observations (or Sum Wgts)	133

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Reflective Level	2	2	106	3.3861	0.0375
Course	2	2	105.9	13.1292	<.0001
Age	1	1	20.52	7.1767	0.0142

Effect Details

Reflective Level

Least Squares Means Table

Level	Least Sq Mean	Std Error
Low	180.74256	17.051621
Medium	206.91272	17.062720
High	205.48860	17.058360

Course

Least Squares Means Table

Level	Least Sq Mean	Std Error
Closed-Rural	227.42789	16.231528
Open-Rural	176.55043	16.966591
Open-Urban	189.16557	18.693632

Age

Least Squares Means Table

Level	Least Sq Mean	Std Error
Old	155.90032	24.410465
Young	239.52894	19.700164

Analysis by Reflective Level

Researchers were also interested in determining if there was a statistically significant difference between the internally illuminated and the reflective sheeting when a reflective level is fixed. Only the data collected on the closed course were used for this test.

Analysis for Low Reflective Level Warning Signs

Table 81 contains the results obtained under the model with Age and Reflectivity Type as main factors, Age*Reflectivity Type as a two-way interaction, and Drivers (nested within Age) as a random effects when Reflective Level is fixed at Low. As can be observed from the table,

there was a significant interaction effect between Age and Reflectivity Type, which suggests that the effect of Reflectivity Type is different for Young and Old drivers.

Table 81. Effect of Reflectivity Type for Low Reflective Warning Signs.

Response Legibility Distance (ft) Reflective Level=Low

Summary of Fit

RSquare	0.912194
RSquare Adj	0.905769
Root Mean Square Error	36.26244
Mean of Response	209.2189
Observations (or Sum Wgts)	45

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age	1	1	20.59	7.0837	0.0148
Reflectivity Type	1	1	20.55	0.3207	0.5773
Age*Reflectivity Type	1	1	20.55	9.0177	0.0069

Effect Details

Age

Least Squares Means Table

Level	Least Sq Mean	Std Error
Old	166.22253	23.639262
Young	247.43396	19.293491

Analysis ID[Age]

Reflectivity Type

Least Squares Means Table

Level	Least Sq Mean	Std Error
II	203.64426	16.278273
RS	210.01222	16.240928

Age*Reflectivity Type

Least Squares Means Table

Level	Least Sq Mean	Std Error
Old,II	179.92241	25.238852
Old,RS	152.52264	24.828903
Young,II	227.36611	20.565239
Young,RS	267.50181	20.942698

Figure 13 contains the Age*Reflectivity Type interaction plot, which shows that Reflectivity Type (RS) leads to longer legibility distance for young drivers but shorter for old drivers. Table 82 presents the multiple comparison test results, showing which pairs of the least squares means of Figure 13 are significantly different.

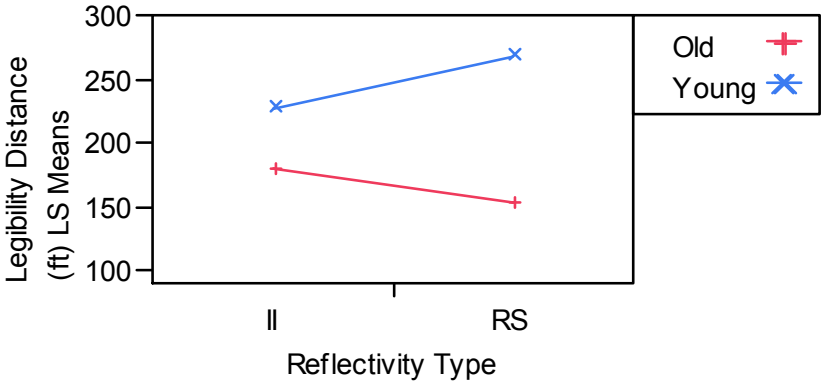


Figure 13. Interaction Plot of Age*Reflectivity Type for Low Reflective Warning Signs.

Table 82. Multiple Comparison Test (Fisher's Protected LSD) for Age*Reflectivity Type.

Level				Least Sq Mean
Young,RS	A			267.50181
Young,II		B		227.36611
Old,II		B	C	179.92241
Old,RS			C	152.52264

Levels not connected by same letter are significantly different.

Analysis for High Reflective Level Warning Signs

Table 83 and Figure 14 contain the results obtained under the model with Age and Reflectivity Type as main factors, Age*Reflectivity Type as a two-way interaction, and Drivers (nested within Age) as a random effects when Reflective Level is fixed at High. As can be observed from the table and the figure, none of the effects in the model were statistically significant in this case.

Table 83. Effect of Reflectivity Type for High Reflective Warning Signs.

Response Legibility Distance (ft) Reflective Level=High

Summary of Fit

RSquare	0.904858
RSquare Adj	0.897896
Root Mean Square Error	43.65789
Mean of Response	242.6797
Observations (or Sum Wgts)	45

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age	1	1	20.91	2.1105	0.1611
Reflectivity Type	1	1	20.09	0.2213	0.6431
Age*Reflectivity Type	1	1	20.09	0.1385	0.7137

Effect Details

Age

Least Squares Means Table

Level	Least Sq Mean	Std Error
Old	208.92688	31.791495
Young	268.21123	25.585843

Reflectivity Type

Least Squares Means Table

Level	Least Sq Mean	Std Error
II	235.42341	21.529030
RS	241.71470	21.414923

Age*Reflectivity Type

Least Squares Means Table

Level	Least Sq Mean	Std Error
Old,II	203.29278	33.415396
Old,RS	214.56098	33.415396
Young,II	267.55404	27.155254
Young,RS	268.86842	26.791921

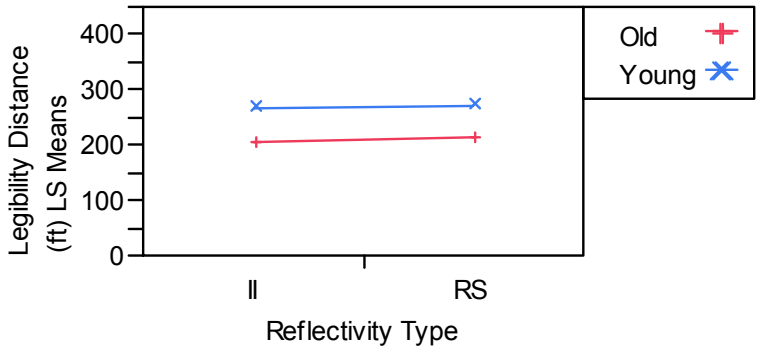


Figure 14. Interaction Plot of Age*Reflectivity Type for High Reflective Warning Signs.

ANALYSIS FOR REGULATORY SIGN

For regulatory signs, half of the signs (#4–#11) were tested with high headlight beams, and the other half were tested with low headlight beams. The data from the regulatory signs tested with low headlight beams and those with high headlight beams are analyzed separately.

ANALYSIS FOR REGULATORY SIGNS TESTED WITH LOW HEADLIGHT BEAMS

Analysis by Reflectivity Type

For regulatory signs, Reflectivity Type II (Internally Illuminated) is present only for Course Type=Closed and for Reflective Level=Low or High. To prevent potential confounding between Reflectivity Type and other factors, data are analyzed separately for each level of Reflectivity Type as in warning signs, rather than just ignoring Reflectivity Type in the analysis.

Analysis for Internally Illuminated Regulatory Signs

A split-plot model with Age and Reflective Level as main effects, Age*Reflective Level as a two-way interaction, and Driver nested within Age as a random effect is used as an initial model for internally illuminated regulatory signs with low headlight beams. Table 84 contains the results obtained by the initial model. It can be observed from the Fixed Effect Tests table that the effect of Reflective Level is significant at α=0.05 and the effect of Age is significant at α=0.1 while the interaction effect is not significant. The Effect Details table for Reflective Level shows the least squares means for legibility distance for each level of Reflective Level and Age, suggesting that a High reflective level leads to longer legibility distance and young drivers tend to see farther.

Table 84. Output for the Initial Model for Internally Illuminated Regulatory Signs.

Response Legibility Distance (ft) Reflectivity Type=II

Summary of Fit

RSquare	0.881998
RSquare Adj	0.873569
Root Mean Square Error	33.05814
Mean of Response	192.7907
Observations (or Sum Wgts)	46

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Reflective Level	1	1	21	15.2580	0.0008
Age	1	1	21	3.0809	0.0938
Age*Reflective Level	1	1	21	0.4021	0.5329

Effect Details

Analysis ID[Age]

Reflective Level

Least Squares Means Table

Level	Least Sq Mean	Std Error
Low	168.26305	14.076572
High	207.27435	14.076572

Age

Least Squares Means Table

Level	Least Sq Mean	Std Error
Old	164.66768	20.536272
Young	210.86972	16.465649

Age*Reflective Level

Least Squares Means Table

Level	Least Sq Mean	Std Error
Old,Low	141.99553	21.964787
Old,High	187.33983	21.964787
Young,Low	194.53058	17.611008
Young,High	227.20887	17.611008

Table 85 contains the reduced model with Reflective Level and Age as main effects and Drivers as random blocks, which leads to basically the same conclusion on the effect of Reflective Level and Age as above.

Table 85. Output for the Reduced Model for Internally Illuminated Regulatory Signs.

Response Legibility Distance (ft) Reflectivity Type=II

Summary of Fit

RSquare	0.880819
RSquare Adj	0.875275
Root Mean Square Error	32.60583
Mean of Response	192.7907
Observations (or Sum Wgts)	46

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Reflective Level	1	1	22	15.3208	0.0007
Age	1	1	21	3.0809	0.0938

Effect Details

Reflective Level

Least Squares Means Table

Level	Least Sq Mean	Std Error
Low	168.95142	14.011630
High	206.58598	14.011630

Age

Least Squares Means Table

Level	Least Sq Mean	Std Error
Old	164.66768	20.536272
Young	210.86972	16.465649

Analysis for Reflective Sheeting Regulatory Signs

For Reflectivity Type RS, there are two levels for Course Type and three levels for Reflective Level. A split-plot model with Age, Reflective Level, and Course Type as main effects, Age*Reflective Level and Course Type*Reflective Level as two-way interactions, and Driver nested within Age as a random effect is used as an initial model. Table 86 contains the results under the initial model, which shows that Reflective Level, Course Type, and Age are statistically significant (see Fixed Effect Tests table). It can be observed from the Effect Details table that High reflective level, Closed course type, and/or Young age corresponds to longer legibility distance.

Table 86. Output for the Initial Model for Reflective Sheeting Regulatory Signs.

Response Legibility Distance (ft) Reflectivity Type=RS
Summary of Fit

RSquare	0.765772
RSquare Adj	0.750286
Root Mean Square Error	46.99962
Mean of Response	177.78
Observations (or Sum Wgts)	130

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Reflective Level	2	2	99.74	6.2584	0.0028
Course Type	1	1	100.3	31.1791	<.0001
Age	1	1	20.57	4.3183	0.0504
Course Type*Reflective Level	2	2	99.86	0.2181	0.8044
Age*Reflective Level	2	2	99.76	1.0973	0.3378

Effect Details
Analysis ID[Age]

Reflective Level
Least Squares Means Table

Level	Least Sq Mean	Std Error
Low	160.22450	15.597883
Medium	158.27378	15.626930
High	191.25972	15.764667

Course Type
Least Squares Means Table

Level	Least Sq Mean	Std Error
Closed	193.30804	15.034800
Open	146.53063	15.127167

Age
Least Squares Means Table

Level	Least Sq Mean	Std Error
Old	139.80636	22.565109
Young	200.03231	18.181824

Course Type*Reflective Level
Least Squares Means Table

Level	Least Sq Mean	Std Error
Closed,Low	187.12958	17.041099
Closed,Medium	181.34947	17.172540
Closed,High	211.44507	17.252387
Open,Low	133.31942	17.177897
Open,Medium	135.19809	17.179205
Open,High	171.07438	17.659201

Age*Reflective Level
Least Squares Means Table

Level	Least Sq Mean	Std Error
Old,Low	126.55208	24.290479
Old,Medium	136.91325	24.290479
Old,High	155.95376	24.469566
Young,Low	193.89693	19.574179
Young,Medium	179.63431	19.666632
Young,High	226.56568	19.921188

Table 87 contains the reduced model with Reflective Level, Course Type, and Age as main effects and Drivers (nested within Age) as random effects, which leads to basically the same conclusions on the effects of Reflective Level, Course Type, and Age as above.

Table 87. Output for the Reduced Model for Reflective Sheeting Regulatory Signs.

Response Legibility Distance (ft) Reflectivity Type=RS
Summary of Fit

RSquare	0.759947
RSquare Adj	0.752265
Root Mean Square Error	46.67855
Mean of Response	177.78
Observations (or Sum Wgts)	130

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Reflective Level	2	2	103.8	7.0411	0.0014
Course Type	1	1	104.3	32.7597	<.0001
Age	1	1	20.56	4.2565	0.0520

Effect Details
Analysis ID[Age]

Reflective Level
Least Squares Means Table

Level	Least Sq Mean	Std Error
Low	161.04702	15.536355
Medium	156.72537	15.572574
High	191.89908	15.706098

Course Type
Least Squares Means Table

Level	Least Sq Mean	Std Error
Closed	193.63378	15.021122
Open	146.14719	15.108651

Age
Least Squares Means Table

Level	Least Sq Mean	Std Error
Old	140.01070	22.557525
Young	199.77028	18.170004

Table 88 contains the Tukey's multiple comparison test results, suggesting that for Reflective Level, High is significantly different from Low and Medium while Low and Medium are not significantly different.

Table 88. Tukey's Multiple Comparison Test for Reflective Level for Reflective Sheeting Regulatory Signs.

Level			Least Sq Mean
High	A		191.89908
Low		B	161.04702
Medium		B	156.72537

Levels not connected by same letter are significantly different.

Analysis by Reflective Level

Researchers were also interested in determining if there was a statistically significant difference between the internally illuminated and the reflective sheeting when a reflective level is fixed for regulatory signs. Only the data collected on the closed course were used for this test.

Analysis for Low Reflective Level Regulatory Signs

Table 89 contains the results obtained under the model with Age and Reflectivity Type as main factors, Age*Reflectivity Type as a two-way interaction, and Drivers (nested within Age) as a random effects when Reflective Level is fixed at Low. Only the effect of Age is statistically significant in this case although the interaction plot presented in Figure 15 indicates that young drivers might see reflective sheeting signs better than internally illuminated signs as in the case of warning signs. However, this interaction effect is not statistically significant (partly due to a small sample size).

Table 89. Effect of Reflectivity Type for Low Reflective Regulatory Signs.

Response Legibility Distance (ft) Reflective Level=Low
Summary of Fit

RSquare	0.882716
RSquare Adj	0.874338
Root Mean Square Error	36.81559
Mean of Response	184.2115
Observations (or Sum Wgts)	46

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age	1	1	21	5.9531	0.0236
Reflectivity Type	1	1	21	2.2527	0.1483
Age*Reflectivity Type	1	1	21	2.4475	0.1327

Effect Details
Analysis ID[Age]

Age
Least Squares Means Table

Level	Least Sq Mean	Std Error
Old	141.64220	22.362796
Young	211.57753	17.930126

Reflectivity Type
Least Squares Means Table

Level	Least Sq Mean	Std Error
II	168.26305	15.372785
RS	184.95667	15.372785

Age*Reflectivity Type
Least Squares Means Table

Level	Least Sq Mean	Std Error
Old,II	141.99553	23.987371
Old,RS	141.28886	23.987371
Young,II	194.53058	19.232683
Young,RS	228.62447	19.232683

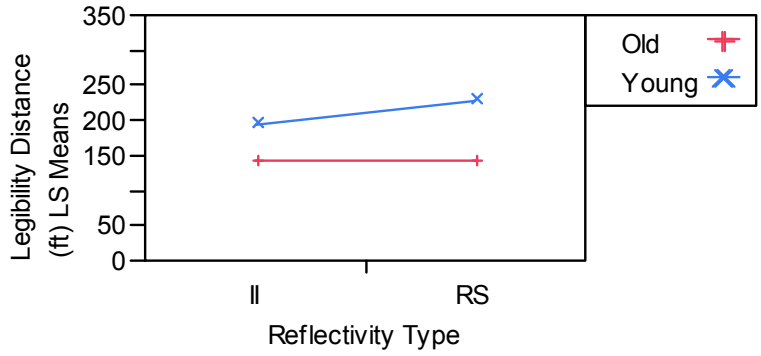


Figure 15. Interaction Plot of Age*Reflectivity Type for Low Reflective Regulatory Signs.

Analysis for High Reflective Level Regulatory Signs

Table 90 and Figure 16 contain the results obtained under the model with Age and Reflectivity Type as main factors, Age*Reflectivity Type as a two-way interaction, and Drivers

(nested within Age) as a random effects when Reflective Level is fixed at High. As can be observed from the table and the figure, none of the effects in the model was statistically significant in this case.

Table 90. Effect of Reflectivity Type for High Reflective Regulatory Signs.

Response Legibility Distance (ft) Reflective Level=High
Summary of Fit

RSquare	0.92367
RSquare Adj	0.918085
Root Mean Square Error	31.84282
Mean of Response	218.0674
Observations (or Sum Wgts)	45

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age	1	1	20.91	2.8492	0.1063
Reflectivity Type	1	1	20.05	0.1211	0.7314
Age*Reflectivity Type	1	1	20.05	2.6128	0.1216

Effect Details
Analysis ID[Age]

Age
Least Squares Means Table

Level	Least Sq Mean	Std Error
Old	181.02272	25.920339
Young	236.99288	20.678958

Reflectivity Type
Least Squares Means Table

Level	Least Sq Mean	Std Error
II	207.27435	17.214451
RS	210.74125	17.407346

Age*Reflectivity Type
Least Squares Means Table

Level	Least Sq Mean	Std Error
Old,II	187.33983	26.861068
Old,RS	174.70560	27.353801
Young,II	227.20887	21.536767
Young,RS	246.77689	21.536767

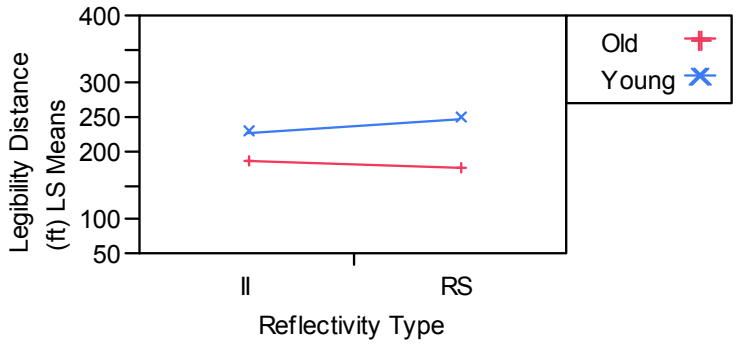


Figure 16. Interaction Plot of Age*Reflectivity Type for High Reflective Regulatory Signs.

Analysis for Regulatory Signs Tested with High Headlight Beams

Signs numbered 4–11 are analyzed here. These regulatory signs were tested with Course Type=Closed, Course Setting = Rural, Reflectivity Type = Reflective Sheeting, and Letter Height = 10. Reflective Level has two levels: Low (corresponding to Signs 4, 6, 7, 11) and Medium (corresponding to Signs 5, 8, 9, 10) in this experiment. Researchers were interested in testing whether there is a significant difference between Low and Medium reflective levels under high beam headlight illumination. A split-plot model with Age and Reflective Level as main effects, and Age*Reflective Level as a two-way interaction, and Driver nested within Age as a random effect is used as an initial model for reflective sheeting regulatory signs with high headlight beams. It was assumed that sign ordering does not significantly affect the effect of Reflective Level on legibility distance. Table 91 contains the results obtained by the initial model. It can be observed from the Fixed Effect Tests table that the effect of Reflective Level is significant at α=0.05, and the effect of Age is significant at α=0.1 while the interaction effect is not significant. The Effect Details table for Reflective Level shows the least squares means for legibility distance for each level of Reflective Level and Age, suggesting that Medium reflective level leads to longer legibility distance than Low reflective level and young drivers tend to see farther.

Table 91. Output for the Initial Model for Reflective Sheeting Regulatory Signs with High Headlight Beams.

Response Legibility Distance (ft)
Summary of Fit

RSquare	0.809391
RSquare Adj	0.806067
Root Mean Square Error	59.91966
Mean of Response	338.0146
Observations (or Sum Wgts)	176

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Reflective Level	1	1	151	11.7140	0.0008
Age	1	1	20.95	2.9668	0.0997
Age*Reflective Level	1	1	151	0.6581	0.4185

Effect Details
Reflective Level
Least Squares Means Table

Level	Least Sq Mean	Std Error
Low	316.19517	24.440911
Medium	347.73245	24.464429

Age
Least Squares Means Table

Level	Least Sq Mean	Std Error
Old	290.60005	37.455088
Young	373.32757	30.065636

Age*Reflective Level
Least Squares Means Table

Level	Least Sq Mean	Std Error
Old,Low	271.09380	38.104440
Old,Medium	310.10630	38.146481
Young,Low	361.29655	30.618362
Young,Medium	385.35859	30.641136

Table 92 contains the reduced model with Reflective Level and Age as main effects and Drivers (nested within Age) as random effects, which leads to basically the same conclusions on the effects of Reflective Level and Age as above.

Table 92. Output for the Reduced Model for Reflective Sheeting Regulatory Signs with High Headlight Beams.

Response Legibility Distance (ft)
Summary of Fit

RSquare	0.808555
RSquare Adj	0.806342
Root Mean Square Error	59.85432
Mean of Response	338.0146
Observations (or Sum Wgts)	176

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Reflective Level	1	1	152	11.1031	0.0011
Age	1	1	20.95	2.9756	0.0993

Effect Details

Reflective Level
Least Squares Means Table

Level	Least Sq Mean	Std Error
Low	316.89864	24.418711
Medium	346.98942	24.440412

Age
Least Squares Means Table

Level	Least Sq Mean	Std Error
Old	290.52954	37.445603
Young	373.35852	30.058022

Analysis for Guide Sign

Guide signs were tested only on the open course with two course setting levels (Rural and Urban). A split-plot model with Age, Reflective Level, and Course Setting as main effects, Age*Reflective Level and Course Setting*Reflective Level as two-way interactions, and Driver nested within Age as a random effect is employed for guide signs. Table 93 contains the results. It can be observed from the Fixed Effect Tests table that the effect of Course Setting *Reflective Level is significant at α=0.05, and the effect of Age*Reflective Level is significant at α=0.1.

Table 93. Output for the Model for Guide Signs.

Response Legibility Distance (ft)
Summary of Fit

RSquare	0.901249
RSquare Adj	0.886343
Root Mean Square Error	45.06829
Mean of Response	260.059
Observations (or Sum Wgts)	62

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age	1	1	20.03	8.3228	0.0091
Reflective Level	2	2	34.38	1.3617	0.2697
Course Setting	1	1	32.98	1.4839	0.2318
Age*Reflective Level	2	2	33.67	3.2714	0.0503
Course Setting*Reflective Level	2	2	39.52	5.7090	0.0066

Effect Details
Analysis ID[Age]

Age
Least Squares Means Table

Level	Least Sq Mean	Std Error
Old	188.59086	30.304170
Young	301.88137	24.954696

Reflective Level
Least Squares Means Table

Level	Least Sq Mean	Std Error
Low	235.25082	22.064835
Medium	239.44966	21.197345
High	261.00786	22.011683

Course Setting
Least Squares Means Table

Level	Least Sq Mean	Std Error
Rural	237.75478	20.045620
Urban	252.71744	21.062463

Age*Reflective Level
Least Squares Means Table

Level	Least Sq Mean	Std Error
Old,Low	167.47999	34.326215
Old,Medium	204.99990	32.309224
Old,High	193.29269	34.221725
Young,Low	303.02164	27.036752
Young,Medium	273.89942	27.859677
Young,High	328.72304	27.034888

Course Setting*Reflective Level
Least Squares Means Table

Level	Least Sq Mean	Std Error
Rural,Low	193.38629	23.398269
Rural,Medium	268.92484	23.625073
Rural,High	250.95322	23.414677
Urban,Low	277.11534	28.262683
Urban,Medium	209.97448	26.843192
Urban,High	271.06251	28.098771

Figure 17 contains the Age*Reflective Level interaction plot, which shows that the effect of Reflective Level on legibility distance is somewhat different for different Age group. Table 94 presents the Fisher's protected LSD multiple comparison test results.

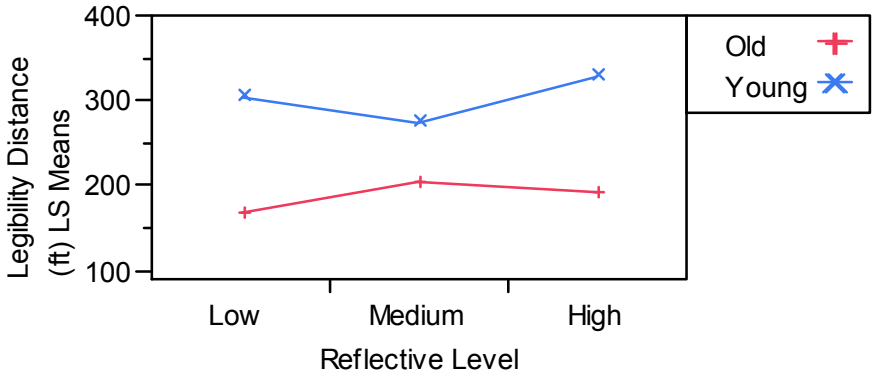


Figure 17. Interaction Plot of Age*Reflective Level for Guide Signs.

Table 94. Multiple Comparison Test (Fisher's Protected LSD) for Age*Reflective Level.

Level					Least Sq Mean
Young,High	A				328.72304
Young,Low	A	B			303.02164
Young,Medium		B	C		273.89942
Old,Medium			C	D	204.99990
Old,High			C	D	193.29269
Old,Low				D	167.47999

Levels not connected by same letter are significantly different.

Figure 18 contains the Course Setting*Reflective Level interaction plot, which shows that the effect of Reflective Level on legibility distance is different for Rural and Urban. Table 95 presents the Fisher's protected LSD multiple comparison test results. It can be concluded that for Rural Course Setting, Medium and High Reflective Levels lead to longer legibility distances than Low Reflective Level while there is no significant difference between Medium and High. Also, Low Reflective Level seems to work better under the urban course setting than under the rural course setting.

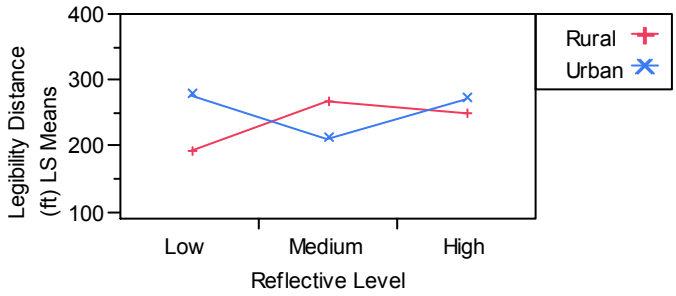


Figure 18. Interaction Plot of Course Setting*Reflective Level for Guide Signs.

Table 95. Multiple Comparison Test (Fisher's Protected LSD) for Course Setting*Reflective Level.

Level				Least Sq Mean
Urban,Low	A			277.11534
Urban,High	A	B		271.06251
Rural,Medium	A			268.92484
Rural,High	A	B		250.95322
Urban,Medium		B	C	209.97448
Rural,Low			C	193.38629

Levels not connected by same letter are significantly different.

Analysis for Street Name Sign

Street name signs were tested only on the open course with two course setting levels (Rural and Urban). A split-plot model with Age, Reflective Level, and Course Setting as main effects, Age*Reflective Level and Course Setting *Reflective Level as two-way interactions, and Driver nested within Age as a random effect is employed for street name signs. Table 96 contains the results of running the initial model for Street Name signs . It can be observed from the Fixed Effect Tests table that the effects of Age and Course Setting are significant at α=0.05 while the effect of Reflective Level as well as interaction effects are all insignificant.

Table 96. Output for the Initial Model for Street Name Signs.

Response Legibility Distance (ft)
Response Legibility Distance (ft)
Summary of Fit

RSquare	0.706014
RSquare Adj	0.663252
Root Mean Square Error	46.6137
Mean of Response	144.476
Observations (or Sum Wgts)	64

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age	1	1	19.9	7.9853	0.0105
Reflective Level	2	2	38.97	0.7032	0.5012
Course Setting	1	1	36.59	7.0543	0.0116
Age*Reflective Level	2	2	36.15	0.4474	0.6428
Course Setting*Reflective Level	2	2	52.3	0.4347	0.6498

Effect Details
Analysis ID[Age]

Age
Least Squares Means Table

Level	Least Sq Mean	Std Error
Old	103.11011	16.721015
Young	164.49205	14.163814

Reflective Level
Least Squares Means Table

Level	Least Sq Mean	Std Error
Low	123.33004	13.759472
Medium	138.25565	15.501477
High	139.81756	14.231081

Course Setting
Least Squares Means Table

Level	Least Sq Mean	Std Error
Rural	116.77320	13.826656
Urban	150.82896	11.632595

Age*Reflective Level
Least Squares Means Table

Level	Least Sq Mean	Std Error
Old,Low	99.07607	21.195732
Old,Medium	100.17665	21.347442
Old,High	110.07762	21.999648
Young,Low	147.58400	17.327816
Young,Medium	176.33465	20.298938
Young,High	169.55751	17.544086

Course Setting*Reflective Level
Least Squares Means Table

Level	Least Sq Mean	Std Error
Rural,Low	96.84873	20.081651
Rural,Medium	130.55672	25.693598
Rural,High	122.91416	20.910553
Urban,Low	149.81135	16.697093
Urban,Medium	145.95457	15.492790
Urban,High	156.72097	16.874346

Table 97 contains the reduced model with main effects only and Drivers (nested within Age) as random effect, which leads to the same conclusions on the effects of Age, Reflective Level, and Course Setting as above. For street name signs, it appears that signs can be seen better (i.e., have longer legibility distance) under Urban setting than under Rural setting. Also, Reflective Level does not seem to matter.

Table 97. Output for the Reduced Model for Street Name Signs.

Response Legibility Distance (ft)
Summary of Fit

RSquare	0.705517
RSquare Adj	0.685552
Root Mean Square Error	44.99042
Mean of Response	144.476
Observations (or Sum Wgts)	64

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age	1	1	19.91	7.3154	0.0137
Reflective Level	2	2	39.29	0.6777	0.5136
Course Setting	1	1	39.09	9.8135	0.0033

Effect Details

Age
Least Squares Means Table

Level	Least Sq Mean	Std Error
Old	102.79730	16.856868
Young	161.73475	14.047083

Reflective Level
Least Squares Means Table

Level	Least Sq Mean	Std Error
Low	123.77400	13.407187
Medium	133.33002	13.911187
High	139.69406	13.686420

Course Setting
Least Squares Means Table

Level	Least Sq Mean	Std Error
Rural	113.44124	13.425691
Urban	151.09081	11.663161

CHAPTER 4: STATISTICAL RESULTS FROM EYE-TRACKER DATA FROM PHASE III

INTRODUCTION

In this chapter, detailed statistical testing results are presented for the eye-tracker data obtained from Phase III of the study. The objective of this analysis was to assess the effect of sign reflective levels on the number of Glances (within 40LI), legibility glance duration, average glance duration without the legibility glance (measured in sec), total glance duration (within 40LI), and legibility glance start distance (measured in feet). The dependent variable of the analysis is each of these five variables, Number of Glances within 40LI, Leg. Glance Duration, Avg. Glance Duration W/O Leg, Total Glance Duration within 40LI, and Legibility Glance Start Distance. The main factor of interest is Reflective Level (Low, Medium, High). Other variables considered in the analysis are driver's Age (Old: ≥ 55 years, Young: < 55 years), Reflectivity Type (II: Internally Illuminated, RS: Reflective Sheeting), Course Type (Closed, Open), Course Setting (Rural, Urban), Letter Height (6, 7, 8, 10), and Headlight Beam Type (Low, High). Although there were some additional variables such as Gender, Ethnicity, Employment, and Education in the original data, those variables turned out to be insignificant when included in the models explored and are not considered here.

There are four different sign types: Warning, Regulatory, Guide, and Street Name. Analyses are conducted separately by sign type. For each sign type, the data are analyzed utilizing the split-plot design with Subject (driver) as a whole-plot and each treatment combination as a split-plot in the cases where there are repeated measures for each driver (to account for correlation among the measurements from the same driver). The variable Age is treated as a whole plot factor while some of the remaining variables mentioned above serve as split-plot factors. In the cases where there was mostly one measurement for each driver, the ordinary Analysis of Variance (ANOVA) was employed. For a discrete response variable Number of Glances, both the original Number of Glances and the transformed Number of Glances (z=(y+3/8)1/2 where y is the number of glances) were analyzed in case that the underlying analysis assumptions such as normality and a constant variance assumption for errors are violated for the original variable. There were no noticeable differences between two analyses, and only the results based on the original variable are reported here (the results of these analyses are available by contacting the authors).

It needs to be noted that for these data, not all conditions were replicated throughout the study, and except for Age and Reflective Level, the levels of other factors/variables are different for different sign types (i.e., factor levels are nested within each sign type). Refer to Report 0-5235-1 Volume 1 to find the levels of factors/variables existing for each sign type.

ANALYSIS FOR WARNING SIGNS

Analysis by Reflectivity Type (Main Study Factor: Reflective Level)

For warning signs, Reflectivity Type II (Internally Illuminated) is present only for Course Type=Closed and Course Setting=Rural, and for Reflective Level = Low or High. To prevent potential confounding between Reflectivity Type and other factors, data are analyzed separately for each level of Reflectivity Type, rather than just ignoring Reflectivity Type in the analysis.

Analysis for Internally Illuminated Warning Signs

A split-plot model with Age and Reflective Level as main effects, Age*Reflective Level as a two-way interaction, and Driver nested within Age as a random effect is used for internally illuminated warning signs. Tables 98–102 contain the results obtained for each of the five dependent variables (1)–(5). It can be seen from the tables that none of Age, Reflective Level, or Age*Reflective effects were significant at α=0.05 for any of the five dependent variables in this case. Note that in Table 100 the number of observations for Avg. Glance Duration W/O Leg. (sec) was much smaller than the other cases due to many missing values. Table 101 contains the Least Squares (LS) means plot for Age*Reflective effect (interaction plot) for information purposes although the effect was not significant at at α=0.05.

Table 98. Output for the Analysis on Number of Glances for Internally Illuminated Warning Signs.

Response Number of Glances (within 40LI) Reflectivity Type=II
Summary of Fit

RSquare	0.299993
RSquare Adj	0.232251
Root Mean Square Error	0.759314
Mean of Response	1.485714
Observations (or Sum Wgts)	35

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Reflective Level	1	1	15.17	1.0802	0.3149
Age	1	1	15.61	2.0324	0.1737
Age*Reflective Level	1	1	15.17	1.3247	0.2676

Table 99. Output for the Analysis on Leg. Glance Duration for Internally Illuminated Warning Signs.

Response Leg Glance Duration Reflectivity Type=II
Summary of Fit

RSquare	0.645507
RSquare Adj	0.611201
Root Mean Square Error	1.317116
Mean of Response	2.368571
Observations (or Sum Wgts)	35

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Reflective Level	1	1	13.01	0.7008	0.4176
Age	1	1	14.62	0.0036	0.9528
Age*Reflective Level	1	1	13.01	0.0003	0.9868

Table 100. Output for the Analysis on Avg. Glance Duration W/O Leg. (sec) for Internally Illuminated Warning Signs.

Response Avg_ Glance Duration W/O Leg_ Reflectivity Type=II
Summary of Fit

RSquare	0.818868
RSquare Adj	0.75849
Root Mean Square Error	0.392291
Mean of Response	0.796154
Observations (or Sum Wgts)	13

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Reflective Level	1	1	3.201	0.0061	0.9425
Age	1	1	4.587	0.2348	0.6503
Age*Reflective Level	1	1	3.201	1.5812	0.2925

Table 101. Output for the Analysis on Total Glance Duration within 40LI for Internally Illuminated Warning Signs.

Response Total Glance Duration Reflectivity Type=II

Summary of Fit

RSquare	0.788207
RSquare Adj	0.76771
Root Mean Square Error	1.085528
Mean of Response	3.022857
Observations (or Sum Wgts)	35

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Reflective Level	1	1	13.76	3.6463	0.0773
Age	1	1	15.83	0.7015	0.4147
Age*Reflective Level	1	1	13.76	2.9515	0.1082

Effect Details

Reflective Level

Least Squares Means Table

Level	Least Sq Mean	Std Error
Low	2.7971916	0.40993860
High	3.5288620	0.42290700

Age*Reflective Level

Least Squares Means Table

Level	Least Sq Mean	Std Error
Old,Low	2.7777778	0.58441857
Old,High	4.1677240	0.63875721
Young,Low	2.8166054	0.57502483
Young,High	2.8900000	0.55442813

LS Means Plot

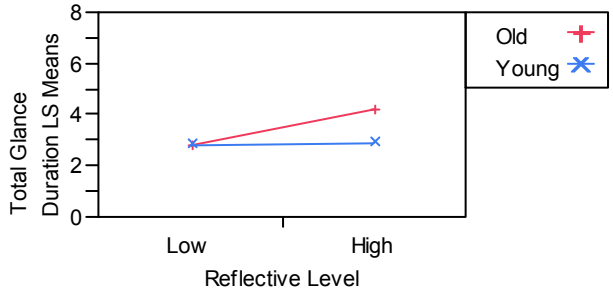


Table 102. Output for the Analysis on Legibility Glance Start Distance for internally Illuminated Warning Signs.

Response Legibility Glance Start Distance (ft) Reflectivity Type=II
Summary of Fit

RSquare	0.772274
RSquare Adj	0.750236
Root Mean Square Error	91.28628
Mean of Response	335.6742
Observations (or Sum Wgts)	35

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Reflective Level	1	1	13.36	0.6478	0.4350
Age	1	1	15.4	1.3465	0.2636
Age*Reflective Level	1	1	13.36	0.1230	0.7312

Analysis for Reflective Sheeting Warning Signs

For Reflectivity Type RS, there are two levels for each of Course Type and Course Setting. To get a better understanding of the effects of Course Type and Course Setting as well as their joint effect on legibility distance, factors 'Course Type' and 'Course Setting' are combined into a new factor 'Course' with three levels (Closed-Rural, Open-Rural, Open-Urban) for Reflective Sheeting Warning signs. A split-plot model with Age, Reflective Level, and Course as main effects, Age*Reflective Level and Course*Reflective Level as two-way interactions, and Driver nested within Age as a random effect is employed.

Tables 103–107 contain the results obtained for each of the five dependent variables (1)–(5) for reflective sheeting warning signs. It can be seen from Tables 6 and 7 that none of Age, Reflective Level, Course, Age*Reflective, or Course*Reflective effects were significant at α=0.05 for Number of Glances as well as for Leg. Glance Duration.

Table 103. Output for the Analysis on Number of Glances for Reflective Sheeting Warning Signs.

Response Number of Glances (within 40LI) Reflectivity Type=RS
Summary of Fit

RSquare	0.533992
RSquare Adj	0.473685
Root Mean Square Error	0.548987
Mean of Response	1.391753
Observations (or Sum Wgts)	97

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Reflective Level	2	2	71.14	0.2810	0.7559
Course	2	2	71.44	1.0294	0.3625

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age	1	1	18.68	2.2975	0.1463
Reflective Level*Course	4	4	75.32	1.2059	0.3154
Age*Reflective Level	2	2	70.76	1.0256	0.3639

Table 104. Output for the Analysis on Leg. Glance Duration for Reflective Sheeting Warning Signs.

Response Leg Glance Duration Reflectivity Type=RS
Summary of Fit

RSquare	0.447087
RSquare Adj	0.375534
Root Mean Square Error	1.339611
Mean of Response	2.131959
Observations (or Sum Wgts)	97

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Reflective Level	2	2	69.77	0.1448	0.8655
Course	2	2	70.09	0.3413	0.7120
Age	1	1	17.04	0.4490	0.5118
Reflective Level*Course	4	4	74.33	1.1858	0.3241
Age*Reflective Level	2	2	69.36	2.1618	0.1228

Due to a very low sample size (n = 28), the above model could not be fitted to Avg. Glance Duration W/O Leg. Instead, the model with Age, Reflective Level, and Course as main effects, Age*Reflective Level as a two-way interaction, and Driver nested within Age as a random effect was fitted to Avg. Glance Duration W/O Leg (see Table 105). Again, none of Age, Reflective Level, Course, or Age*Reflective effects were significant at α=0.05 although Age*Reflective was significant at α=0.1. The LS means plot for Age*Reflective effect (interaction plot) is also provided in Table 105 for information purposes.

Table 105. Output for the Analysis on Avg. Glance Duration W/O Leg. (sec) for Reflective Sheeting Warning Signs.

Response Avg_ Glance Duration W/O Leg_ Reflectivity Type=RS
Summary of Fit

RSquare	0.581143
RSquare Adj	0.434543
Root Mean Square Error	0.564313
Mean of Response	0.860417
Observations (or Sum Wgts)	28

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age	1	1	9.761	1.1194	0.3155
Reflective Level	2	2	17.4	1.6599	0.2189
Age*Reflective Level	2	2	17.06	3.3082	0.0611
Course	2	2	15.05	2.3663	0.1278

Effect Details
Age*Reflective Level
Least Squares Means Table

Level	Least Sq Mean	Std Error
Old,Low	0.4945816	0.28598906
Old,Medium	0.2752184	0.40346514
Old,High	1.0132800	0.36815260
Young,Low	1.8093706	0.49086670
Young,Medium	0.7703701	0.41555960
Young,High	0.2529118	0.36502636

LS Means Plot

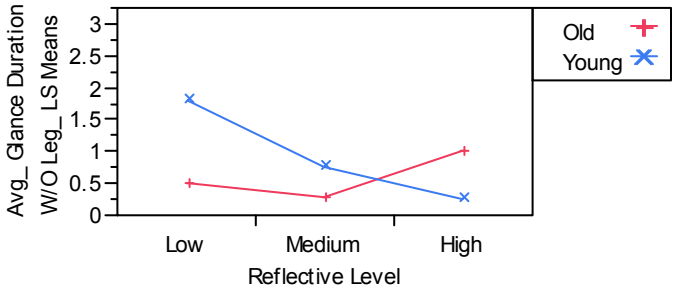


Table 106 contains the results under the model with Age, Reflective Level, and Course as main effects, Age*Reflective Level and Course*Reflective Level as two-way interactions, and Driver nested within Age as a random effect. Again, none of Age, Reflective Level, Course, Course*Reflective Level or Age*Reflective effects were significant at α=0.05. The Least Squares means plot for Age*Reflective effect (interaction plot) is provided in Table 106 for information purposes only.

Table 106. Output for the Analysis on Total Glance Duration within 40LI for Reflective Sheeting Warning Signs.

Response Total Glance Duration Reflectivity Type=RS
Summary of Fit

RSquare	0.462991
RSquare Adj	0.393495
Root Mean Square Error	1.340388
Mean of Response	2.684536
Observations (or Sum Wgts)	97

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Reflective Level	2	2	70.38	0.4294	0.6526
Course	2	2	70.69	1.0867	0.3429
Age	1	1	17.71	1.0656	0.3158
Reflective Level*Course	4	4	74.8	0.1155	0.9767
Age*Reflective Level	2	2	69.98	2.2318	0.1149

Effect Details

Age*Reflective Level
Least Squares Means Table

Level	Least Sq Mean	Std Error
Old,Low	2.8382362	0.47914663
Old,Medium	2.5386753	0.48808390
Old,High	3.3988259	0.52458431
Young,Low	2.8036442	0.44744692
Young,Medium	2.4071999	0.44917133
Young,High	1.9860003	0.46364928

LS Means Plot

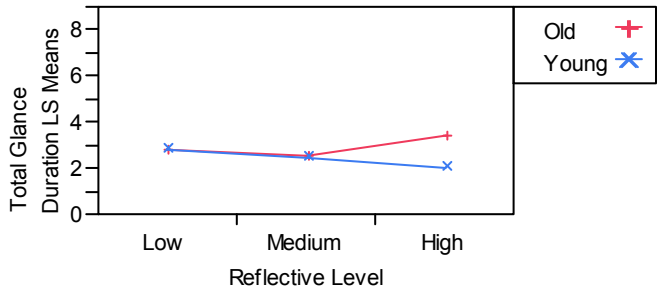


Table 107 contains the results under the model with Age, Reflective Level, and Course as main effects, Age*Reflective Level and Course*Reflective Level as two-way interactions, and Driver nested within Age as a random effect for Legibility Glance Start Distance. Again, none of Age, Reflective Level, Course, Course*Reflective Level or Age*Reflective effects were significant at α=0.05.

Table 107. Output for the Analysis on Legibility Glance Start Distance for Reflective Sheeting Warning Signs.

Response Legibility Glance Start Distance (ft) Reflectivity Type=RS
Summary of Fit

RSquare	0.468436
RSquare Adj	0.399645
Root Mean Square Error	117.862
Mean of Response	336.9237
Observations (or Sum Wgts)	97

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Reflective Level	2	2	69.6	0.8221	0.4437
Course	2	2	69.93	1.0259	0.3638
Age	1	1	16.48	1.2476	0.2800
Reflective Level*Course	4	4	74.64	1.1608	0.3350
Age*Reflective Level	2	2	69.17	1.0781	0.3459

Analysis by Reflective Level (Main Study Factor: Reflectivity Type)

Researchers were also interested in determining if there was a statistically significant difference between the internally illuminated and the reflective sheeting when a reflective level is fixed. Only the data collected on the closed course were used for this test.

Analysis for Low Reflective Level Warning Signs

Tables 108–112 contain the results obtained under the model with Age and Reflectivity Type as main factors, Age*Reflectivity Type as a two-way interaction, and Drivers (nested within Age) as a random effects when Reflective Level is fixed at Low for each of the response variables (1)–(5).

Table 108 shows that there is a significant interaction effect between Age and Reflectivity Type at α=0.1 (although not at α=0.05), which suggests that the effect of Reflectivity Type on Number of Glances may be different for Young and Old drivers.

Table 108. Effect of Reflectivity Type on Number of Glances for Low Reflective Warning Signs.

Response Number of Glances (within 40LI) Reflective Level=Low, Course Type=Closed

Summary of Fit

RSquare	0.634598
RSquare Adj	0.599236
Root Mean Square Error	0.519992
Mean of Response	1.514286
Observations (or Sum Wgts)	35

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age	1	1	16.28	2.6895	0.1202
Reflectivity Type	1	1	17.22	0.8136	0.3795
Age*Reflectivity Type	1	1	17.22	3.4185	0.0817

Effect Details

Age*Reflectivity Type

Least Squares Means Table

Level	Least Sq Mean	Std Error
Old,II	1.4444444	0.21729322
Old,RS	1.9568028	0.21816452
Young,II	1.3660786	0.21707165
Young,RS	1.1897110	0.24563288

LS Means Plot

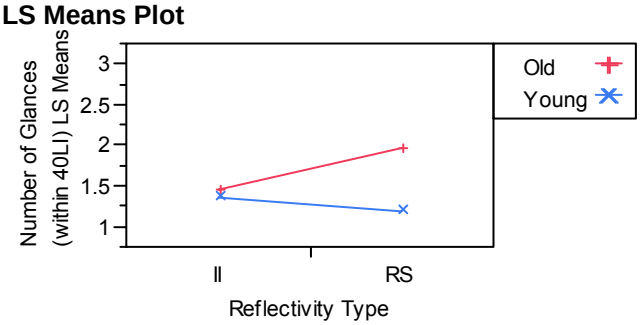


Table 109 shows that none of the effects, Age, Reflectivity Type, and Age*Reflective Type, on Leg. Glance Duration were significant at α=0.05.

Table 109. Effect of Reflectivity Type on Leg. Glance Duration for Reflective Sheeting Warning Signs.

Response Leg Glance Duration Reflective Level=Low, Course Type=Closed

Summary of Fit

RSquare	0.67096
RSquare Adj	0.639118
Root Mean Square Error	1.008801
Mean of Response	1.988571
Observations (or Sum Wgts)	35

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age	1	1	15.35	0.0613	0.8078
Reflectivity Type	1	1	15.42	0.1772	0.6796
Age*Reflectivity Type	1	1	15.42	0.2729	0.6088

Table 110 shows that there is a significant interaction effect between Age and Reflectivity Type at α=0.05, which suggests that the effect of Reflectivity Type on Avg. Glance Duration W/O Leg. (sec) is different for Young and Old drivers. The Age*Reflectivity Type interaction plot is also contained in Table 110, which shows that RS leads to longer Avg. Glance Duration for young drivers but not for old drivers. The multiple comparison test results are also provided in Table 110.

Table 110. Effect of Reflectivity Type on Avg. Glance Duration W/O Leg. (sec) for Reflective Sheeting Warning Signs.

Response Avg_ Glance Duration W/O Leg_ Reflective Level=Low, Course Type=Closed

Summary of Fit

RSquare	0.977594
RSquare Adj	0.970873
Root Mean Square Error	0.22903
Mean of Response	1.022619
Observations (or Sum Wgts)	14

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age	1	1	6.824	2.9027	0.1333
Reflectivity Type	1	1	7.636	5.0165	0.0570
Age*Reflectivity Type	1	1	7.636	7.0536	0.0302

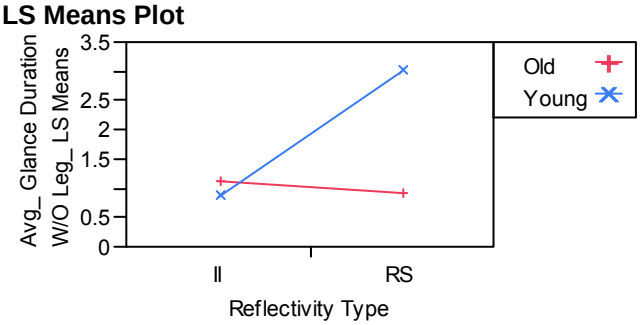
Effect Details

Age*Reflectivity Type

Least Squares Means Table

Level	Least Sq Mean	Std Error
Old,II	1.1145727	0.33543659
Old,RS	0.9304117	0.30676680
Young,II	0.8333333	0.42895886
Young,RS	3.0000000	0.74297854

LS Means Plot



LSMeans Differences Student's t

α=0.050

Level			Least Sq Mean
Young,RS	A		3.0000000
Old,II	A	B	1.1145727
Old,RS		B	0.9304117
Young,II		B	0.8333333

Levels not connected by same letter are significantly different.

Table 111 shows that none of the effects, Age, Reflectivity Type, and Age*Reflective Type, on Total Glance Duration were significant at α=0.05.

Table 111 Effect of Reflectivity Type on Total Glance Duration within 40LI for Reflective Sheeting Warning Signs.

Response Total Glance Duration Reflective Level=Low, Course Type=Closed
Summary of Fit

RSquare	0.785384
RSquare Adj	0.764615
Root Mean Square Error	0.964386
Mean of Response	2.865714
Observations (or Sum Wgts)	35

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age	1	1	15.37	0.1302	0.7232
Reflectivity Type	1	1	14.56	0.6212	0.4432
Age*Reflectivity Type	1	1	14.56	0.7574	0.3983

Table 112 shows that none of the effects, Age, Reflectivity Type, and Age*Reflective Type, on Legibility Glance Start Distance were significant at α=0.05.

Table 112. Effect of Reflectivity Type on Legibility Glance Start Distance for Reflective Sheeting Warning Signs.

Response Legibility Glance Start Distance (ft) Reflective Level=Low, Course Type=Closed
Summary of Fit

RSquare	0.692968
RSquare Adj	0.663255
Root Mean Square Error	91.81648
Mean of Response	307.5127
Observations (or Sum Wgts)	35

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age	1	1	14.91	1.2312	0.2847
Reflectivity Type	1	1	15.04	0.0071	0.9341
Age*Reflectivity Type	1	1	15.04	0.6294	0.4399

Analysis for High Reflective Level Warning Signs

Tables 16–20 contain the results obtained under the model with Age and Reflectivity Type as main factors, Age*Reflectivity Type as a two-way interaction, and Drivers (nested within Age) as a random effects when Reflective Level is fixed at High.

Table 113 shows that there is a significant interaction effect between Age and Reflectivity Type at α=0.05, which suggests that the effect of Reflectivity Type of high reflective level warning sign on Number of Glances is different for Young and Old drivers. The Age*Reflectivity Type interaction plot is also contained in Table 113, which shows that RS leads to a smaller number of glances (compared to II) for old drivers but not for young drivers. The multiple comparison test results are also provided in Table 113.

Table 113. Effect of Reflectivity Type on Number of Glances for High Reflective Level Warning Signs.

Response Number of Glances (within 40LI) Reflective Level=High, Course Type=Closed

Summary of Fit

RSquare	0.884077
RSquare Adj	0.872859
Root Mean Square Error	0.391031
Mean of Response	1.485714
Observations (or Sum Wgts)	35

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age	1	1	16.2	0.7738	0.3919
Reflectivity Type	1	1	15.41	3.1716	0.0947
Age*Reflectivity Type	1	1	15.41	6.3338	0.0234

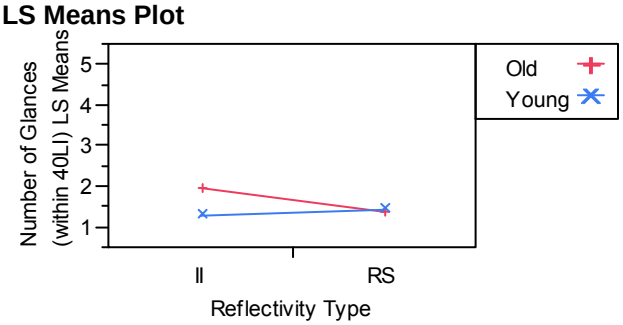
Effect Details

Age*Reflectivity Type

Least Squares Means Table

Level	Least Sq Mean	Std Error
Old,II	1.9590680	0.29340037
Old,RS	1.3750000	0.28462255
Young,II	1.3000000	0.25457415
Young,RS	1.4000000	0.25457415

LS Means Plot



LSMeans Differences Student's t

α=0.050

Level			Least Sq Mean
Old,II	A		1.9590680
Young,RS	A	B	1.4000000
Old,RS		B	1.3750000
Young,II	A	B	1.3000000

Levels not connected by same letter are significantly different.

Table 114 shows that none of the effects, Age, Reflectivity Type, and Age*Reflective Type, on Leg. Glance Duration for high reflective level warning signs were significant at α=0.05.

Table 114. Effect of Reflectivity Type on Leg. Glance Duration for High Reflective Level Warning Signs.

Response Leg Glance Duration Reflective Level=High, Course Type=Closed
Summary of Fit

RSquare	0.415206
RSquare Adj	0.358613
Root Mean Square Error	1.667314
Mean of Response	2.397143
Observations (or Sum Wgts)	35

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age	1	1	15.25	1.2257	0.2854
Reflectivity Type	1	1	15.02	0.2740	0.6083
Age*Reflectivity Type	1	1	15.02	2.1361	0.1645

It was not possible to fit the above model to Avg. Glance Duration without Leg. (sec) due to a very small sample size (n=13). Due to many missing values, there was mostly one measurement for each driver. The ordinary ANOVA with Age and Reflectivity Type as main effects, and Age*Reflectivity Type as a two-way interaction was employed instead (see Table 115). Again, the factors of Age, Reflectivity Type or Age*Reflectivity Type were insignificant at α=0.05.

Table 115. Effect of Reflectivity Type on Avg. Glance Duration W/O Leg. (sec) for High Reflective Level Warning Signs.

Response Avg_ Glance Duration W/O Leg_
Summary of Fit

RSquare	0.202243
RSquare Adj	-0.06368
Root Mean Square Error	0.656726
Mean of Response	0.829487
Observations (or Sum Wgts)	13

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	3	0.9840438	0.328015	0.7605
Error	9	3.8815972	0.431289	**Prob > F**
C. Total	12	4.8656410		0.5440

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.8489583	0.18958	4.48	0.0015
Age[Old]	0.278125	0.18958	1.47	0.1764
Reflectivity Type[II]	-0.071875	0.18958	-0.38	0.7134
Age[Old]*Reflectivity Type[II]	0.0322917	0.18958	0.17	0.8685

Table 116 shows the model with Age and Reflectivity Type as main factors, Age*Reflectivity Type as a two-way interaction, and Drivers (nested within Age) as a random effects fitted to Total Glance Duration for high reflective level warning signs. Only Age shows a significant effect at α=0.1. Based on Least Squares Means table for Age, Total Glance Duration for Old drivers seems to be longer than that for young drivers.

Table 116. Effect of Reflectivity Type on Total Glance Duration for High Reflective Level Warning Signs.

Response Total Glance Duration Reflective Level=High, Course Type=Closed
Summary of Fit

RSquare	0.551691
RSquare Adj	0.508306
Root Mean Square Error	1.511033
Mean of Response	3.077143
Observations (or Sum Wgts)	35

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age	1	1	14.46	4.1001	0.0618
Reflectivity Type	1	1	14.15	1.2054	0.2906
Age*Reflectivity Type	1	1	14.15	0.3475	0.5648

Effect Details
Age
Least Squares Means Table

Level	Least Sq Mean	Std Error
Old	3.8575788	0.52457415
Young	2.4500000	0.45612895

Table 117 shows the model with Age and Reflectivity Type as main factors, Age*Reflectivity Type as a two-way interaction, and Drivers (nested within Age) as random effects fitted to Legibility Glance Start Distance (ft) for high reflective level warning signs. None of the effects seem to be significant.

Table 117. Effect of Reflectivity Type on Legibility Glance Start Distance (ft) for High Reflective Level Warning Signs.

Response Legibility Glance Start Distance (ft) Reflective Level=High, Course Type=Closed
Summary of Fit

RSquare	0.583742
RSquare Adj	0.543459
Root Mean Square Error	129.4489
Mean of Response	357.0381
Observations (or Sum Wgts)	35

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age	1	1	16.28	0.3426	0.5663
Reflectivity Type	1	1	15.87	0.0854	0.7739
Age*Reflectivity Type	1	1	15.87	1.6485	0.2176

ANALYSIS FOR REGULATORY SIGNS

For regulatory signs, speed limit signs (signs #5, 6, 7, and 9) were tested with high headlight beams, and non-speed limit signs were tested with low headlight beams. The data from the regulatory signs tested with low headlight beams and those with high headlight beams (speed limit signs) are analyzed separately.

ANALYSIS FOR REGULATORY SIGNS TESTED WITH LOW HEADLIGHT BEAMS

Analysis by Reflectivity Type (Main Study Factor: Reflective Level)

For regulatory signs, Reflectivity Type II (Internally Illuminated) is present only for Course Type=Closed and for Reflective Level=Low or High. To prevent potential confounding between Reflectivity Type and other factors, data are analyzed separately for each level of Reflectivity Type as in warning signs, rather than just ignoring Reflectivity Type in the analysis.

Analysis for Internally Illuminated Regulatory Signs

A split-plot model with Age and Reflective Level as main effects, Age*Reflective Level as a two-way interaction, and Driver nested within Age as a random effect is used for internally illuminated regulatory signs with low headlight beams. Tables 118–122 contain the results obtained by this model. It can be observed from Table 118 that none of the effects, Age, Reflective Level, or Age*Reflective Level, on Number of Glances were significant at α=0.05.

Table 118. Effect of Reflective Level on Number of Glances for Internally Illuminated Regulatory Signs Tested with Low Headlight Beams.

Response Number of Glances (within 40LI) Reflectivity Type=II

Summary of Fit

RSquare	0.057372
RSquare Adj	-0.03689
Root Mean Square Error	0.657647
Mean of Response	1.352941
Observations (or Sum Wgts)	34

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Reflective Level	1	1	15.24	0.1491	0.7048
Age	1	1	15.24	0.1491	0.7048
Age*Reflective Level	1	1	15.24	1.6094	0.2236

It can be observed from Table 119 that none of the effects, Age, Reflective Level, or Age*Reflective Level, on Leg. Glance Duration were significant at α=0.05.

Table 119. Effect of Reflective Level on Leg. Glance Duration for Internally Illuminated Regulatory Signs Tested with Low Headlight Beams.

Response Leg Glance Duration Reflectivity Type=II
Summary of Fit

RSquare	0.547358
RSquare Adj	0.502094
Root Mean Square Error	1.34682
Mean of Response	2.329412
Observations (or Sum Wgts)	34

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Reflective Level	1	1	14.67	0.9139	0.3546
Age	1	1	15.32	2.8945	0.1091
Age*Reflective Level	1	1	14.67	2.5424	0.1321

Effect Details
Age
Least Squares Means Table

Level	Least Sq Mean	Std Error
Old	2.8500000	0.45840040
Young	1.7808149	0.42989353

It can be observed from Table 120 that none of the effects, Age, Reflective Level, or Age*Reflective Level, on Avg. Glance Duration W/O Leg. (sec) were significant at α=0.05.

Table 120. Effect of Reflective Level on Avg. Glance Duration W/O Leg. (sec) for Internally Illuminated Regulatory Signs Tested with Low Headlight Beams.

Response Avg_ Glance Duration W/O Leg_ Reflectivity Type=II
Summary of Fit

RSquare	0.998951
RSquare Adj	0.998426
Root Mean Square Error	0.100333
Mean of Response	1.1975
Observations (or Sum Wgts)	10

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Reflective Level	1	1	5.033	0.0272	0.8754
Age	1	1	4.984	0.6662	0.4516
Age*Reflective Level	1	1	5.033	0.0023	0.9633

Table 121 shows the result of fitting the model on Total Glance Duration. It can be observed from Table 121 that none of the effects, Age, Reflective Level, or Age*Reflective

Level, on Total Glance Duration were significant at α=0.05. Note that the R^2 value is close to zero.

Table 121. Effect of Reflective Level on Total Glance Duration within 40LI for Internally Illuminated Regulatory Signs Tested with Low Headlight Beams.

Response Total Glance Duration Reflectivity Type=II

Summary of Fit

RSquare	-0.03994
RSquare Adj	-0.14394
Root Mean Square Error	1.752555
Mean of Response	3.055882
Observations (or Sum Wgts)	34

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Reflective Level	1	1	14.89	0.0501	0.8259
Age	1	1	14.84	0.2228	0.6438
Age*Reflective Level	1	1	14.89	0.0334	0.8575

The residual plot contained in Figure 19 reveals three big outliers at the top of the plot. The model was refitted after removing those three outliers. Table 122 presents the result.

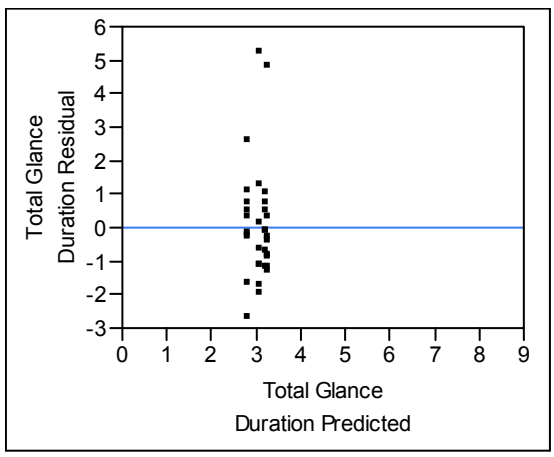


Figure 19. Residual by Predicted Plot for Total Glance Duration within 40LI for Internally Illuminated Regulatory Signs Tested with Low Headlight Beams.

It can be observed from Table 122 that the model fit is considerably improved (in terms of both R^2 and adjusted R^2). Note also that the effect of Reflective level became significant at α=0.05. Total Glance Duration seems to be longer at Low reflective Level.

Table 122. Effect of Reflective Level on Total Glance Duration within 40LI for Internally Illuminated Regulatory Signs Tested with Low Headlight Beams after Removing Three Outliers.

Response Total Glance Duration Reflectivity Type=II

Summary of Fit

RSquare	0.872556
RSquare Adj	0.858396
Root Mean Square Error	0.517686
Mean of Response	2.651613
Observations (or Sum Wgts)	31

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Reflective Level	1	1	8.627	11.8384	0.0079
Age	1	1	12.35	1.3900	0.2606
Age*Reflective Level	1	1	8.627	0.3410	0.5742

Effect Details

Reflective Level

Least Squares Means Table

Level	Least Sq Mean	Std Error
Low	2.9643279	0.26359509
High	2.2665744	0.27603898

LS Means Plot

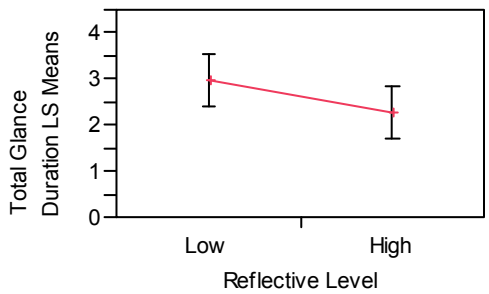


Table 123 shows that none of the effects, Age, Reflective Level, or Age*Reflective Level, on Legibility Glance Start Distance were significant at α=0.05. The LS means plot for Age*Reflective effect (interaction plot) is provided in Table 123 for information purposes only.

Table 123. Effect of Reflective Level on Legibility Glance Start Distance for Internally Illuminated Regulatory Signs Tested with Low Headlight Beams.

Response Legibility Glance Start Distance (ft) Reflectivity Type=II

Summary of Fit

RSquare	0.61142
RSquare Adj	0.572562
Root Mean Square Error	91.61462
Mean of Response	297.373
Observations (or Sum Wgts)	34

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Reflective Level	1	1	15.63	0.1300	0.7233
Age	1	1	16.48	0.3456	0.5646
Age*Reflective Level	1	1	15.63	3.5141	0.0797

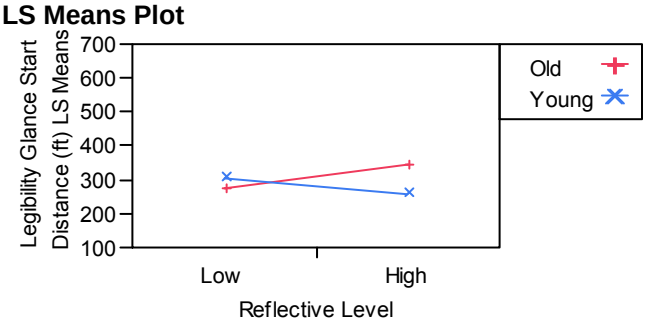
Effect Details

Age*Reflective Level

Least Squares Means Table

Level	Least Sq Mean	Std Error
Old,Low	274.74310	41.760406
Old,High	346.31648	41.760406
Young,Low	306.72578	37.351642
Young,High	258.24233	41.471636

LS Means Plot



Analysis for Reflective Sheeting Regulatory Signs

For Reflectivity Type RS (Reflective Sheeting), there are two levels for Course Type and three levels for Reflective Level. A split-plot model with Age, Reflective Level, and Course Type as main effects, Age*Reflective Level and Course Type*Reflective Level as two-way interactions, and Driver nested within Age as a random effect is used as an initial model. Tables 124–128 contain the results obtained by this model. It can be observed from Table 124 that only the effect of Course Type on Number of Glances is significant at α=0.05.

Table 124. Effect of Reflective Level on Number of Glances for Reflective Sheeting Regulatory Signs Tested with Low Headlight Beams.

Response Number of Glances (within 40LI) Reflectivity Type=RS
Summary of Fit

RSquare	0.262508
RSquare Adj	0.194693
Root Mean Square Error	0.817121
Mean of Response	1.364583
Observations (or Sum Wgts)	96

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Reflective Level	2	2	73.61	0.5338	0.5886
Course Type	1	1	77.81	4.2368	0.0429
Age	1	1	18.66	0.2715	0.6085
Reflective Level*Course Type	2	2	72.79	0.2834	0.7540
Age*Reflective Level	2	2	73.92	0.8527	0.4304

Effect Details

Course Type
Least Squares Means Table

Level	Least Sq Mean	Std Error
Closed	1.5332842	0.13548290
Open	1.1776345	0.14672084

Table 125 shows that none of the effects, Reflective Level, Course Type, Age, Course Type*Reflective Level, and Age*Reflective Level, on Leg Glance Duration were significant at α=0.05.

Table 125. Effect of Reflective Level on Leg Glance Duration for Reflective Sheeting Regulatory Signs Tested with Low Headlight Beams.

Response Leg Glance Duration Reflectivity Type=RS
Summary of Fit

RSquare	0.424735
RSquare Adj	0.371837
Root Mean Square Error	1.747223
Mean of Response	2.876042
Observations (or Sum Wgts)	96

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Reflective Level	2	2	71.39	0.5198	0.5969
Course Type	1	1	74.74	0.4527	0.5031
Age	1	1	17.74	0.4219	0.5243
Reflective Level*Course Type	2	2	70.54	1.5880	0.2115
Age*Reflective Level	2	2	71.62	0.9385	0.3960

Table 126 shows that none of the effects, Reflective Level, Course Type, Age, Course Type*Reflective Level, and Age*Reflective Level, on Avg. Glance Duration W/O Leg. were significant at α=0.05.

Table 126. Effect of Reflective Level on Avg. Glance Duration W/O Leg for Reflective Sheeting Regulatory Signs Tested with Low Headlight Beams.

Response Avg. Glance Duration W/O Leg_ Reflectivity Type=RS

Summary of Fit

RSquare	0.404549
RSquare Adj	-0.02851
Root Mean Square Error	0.643364
Mean of Response	0.732
Observations (or Sum Wgts)	20

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Reflective Level	2	2	6.915	0.1115	0.8961
Course Type	1	1	5.119	0.0286	0.8722
Age	1	1	2.665	0.0025	0.9633
Reflective Level*Course Type	2	2	5.232	0.2833	0.7642
Age*Reflective Level	2	2	7.244	1.0322	0.4032

Table 127 shows that the interaction effect Course Type*Reflective Level on Total Glance Duration was significant at α=0.05.

Table 127. Effect of Reflective Level on Total Glance Duration for Reflective Sheeting Regulatory Signs Tested with Low Headlight Beams.

Response Total Glance Duration Reflectivity Type=RS

Summary of Fit

RSquare	0.474404
RSquare Adj	0.426073
Root Mean Square Error	1.591071
Mean of Response	3.2375
Observations (or Sum Wgts)	96

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Reflective Level	2	2	70.71	0.0565	0.9451
Course Type	1	1	73.92	3.2956	0.0735
Age	1	1	17.25	0.1819	0.6750
Reflective Level*Course Type	2	2	69.86	3.3144	0.0422
Age*Reflective Level	2	2	70.93	1.9189	0.1543

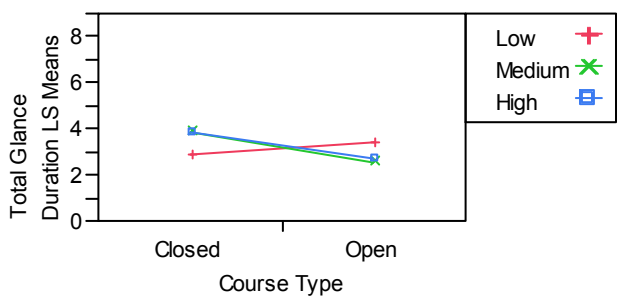
Effect Details

Reflective Level*Course Type

Least Squares Means Table

Level	Least Sq Mean	Std Error
Low,Closed	2.8580795	0.45656828
Low,Open	3.4294726	0.49506649
Medium,Closed	3.8024141	0.47780597
Medium,Open	2.5765979	0.49491206
High,Closed	3.8815299	0.45550397
High,Open	2.6762524	0.50877489

LS Means Plot



LSMeans Differences Student's t

α=0.050

Level				Least Sq Mean
High,Closed	A			3.8815299
Medium,Closed	A	B		3.8024141
Low,Open	A	B	C	3.4294726
Low,Closed	A	B	C	2.8580795
High,Open		B	C	2.6762524
Medium,Open			C	2.5765979

Levels not connected by same letter are significantly different.

Table 128 shows that none of the effects, Reflective Level, Course Type, Age, Course Type*Reflective Level, and Age*Reflective Level, on Legibility Glance Start Distance (ft) were significant at α=0.05.

Table 128. Effect of Reflective Level on Legibility Glance Start Distance (ft) for Reflective Sheeting Regulatory Signs Tested with Low Headlight Beams.

Response Legibility Glance Start Distance (ft) Reflectivity Type=RS
Summary of Fit

RSquare	0.539504
RSquare Adj	0.497159
Root Mean Square Error	136.3328
Mean of Response	374.3103
Observations (or Sum Wgts)	96

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Reflective Level	2	2	71.3	0.8413	0.4354
Course Type	1	1	73.85	2.9032	0.0926
Age	1	1	18.41	0.1410	0.7116
Reflective Level*Course Type	2	2	70.57	1.3251	0.2723
Age*Reflective Level	2	2	71.48	0.2141	0.8078

Analysis by Reflective Level (Main Study Factor: Reflectivity Type)

Researchers were also interested in determining if there was a statistically significant difference between the internally illuminated and the reflective sheeting when a reflective level is fixed for regulatory signs. Only the data collected on the closed course were used for this test.

Analysis for Low Reflective Level Regulatory Signs

The model with Age and Reflectivity Type as main factors, Age*Reflectivity Type as a two-way interaction, and Drivers (nested within Age) as a random effects when Reflective Level is fixed at Low was fitted to each of the response variables (1)–(5). Table 129 shows that none of effects, Age, Reflectivity Type, and Age*Reflectivity Type, on Number of Glances were significant at α=0.05.

Table 129. Effect of Reflectivity Type on Number of Glances for Low Reflective Level Regulatory Signs Tested with Low Headlight Beams.

Response Number of Glances (within 40LI) Reflective Level=Low, Course Type=Closed
Summary of Fit

RSquare	0.631137
RSquare Adj	0.596556
Root Mean Square Error	0.805741
Mean of Response	1.5
Observations (or Sum Wgts)	36

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age	1	1	16	0.6003	0.4498
Reflectivity Type	1	1	16	0.7723	0.3925
Age*Reflectivity Type	1	1	16	0.2589	0.6178

Table 130 shows that none of the effects, Age, Reflectivity Type, Age*Reflectivity Type, on Leg. Glance Duration for low reflective regulatory signs were significant at α=0.05.

Table 130. Effect of Reflectivity Type on Leg. Glance Duration for Low Reflective Level Regulatory Signs Tested with Low Headlight Beams.

Response Leg Glance Duration Reflective Level=Low, Course Type=Closed
Summary of Fit

RSquare	0.440897
RSquare Adj	0.388481
Root Mean Square Error	1.496974
Mean of Response	2.5
Observations (or Sum Wgts)	36

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age	1	1	16	0.6383	0.4360
Reflectivity Type	1	1	16	0.0018	0.9668
Age*Reflectivity Type	1	1	16	0.1729	0.6831

There were only nine observations for Avg. Glance Duration W/O Leg. (sec), and a reasonable model could not be fitted due to an extremely low sample size. Table 131 shows that none of the effects, Age, Reflectivity Type, Age*Reflectivity Type, on Total Glance Duration within 40LI for low reflective regulatory signs were significant at α=0.05.

Table 131. Effect of Reflectivity Type on Total Glance Duration within 40LI for Low Reflective Level Regulatory Signs Tested with Low Headlight Beams.

Response Total Glance Duration Reflective Level=Low, Course Type=Closed
Summary of Fit

RSquare	0.352825
RSquare Adj	0.292152
Root Mean Square Error	1.370857
Mean of Response	2.9
Observations (or Sum Wgts)	36

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age	1	1	16	0.6370	0.4365
Reflectivity Type	1	1	16	0.1211	0.7324
Age*Reflectivity Type	1	1	16	0.0170	0.8978

Table 132 shows that none of the effects, Age, Reflectivity Type, Age*Reflectivity Type, and Legibility Glance Start Distance for low reflective regulatory signs were significant at α=0.05.

Table 132. Effect of Reflectivity Type on Legibility Glance Start Distance for Low Reflective Level Regulatory Signs Tested with Low Headlight Beams.

Response Legibility Glance Start Distance (ft) Reflective Level=Low, Course Type=Closed

Summary of Fit

RSquare	0.527798
RSquare Adj	0.483529
Root Mean Square Error	101.59
Mean of Response	299.852
Observations (or Sum Wgts)	36

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age	1	1	16	0.5502	0.4690
Reflectivity Type	1	1	16	0.1737	0.6823
Age*Reflectivity Type	1	1	16	0.0160	0.9010

Analysis for High Reflective Level Regulatory Signs

Tables 133–137 contain the results obtained under the model with Age and Reflectivity Type as main factors, Age*Reflectivity Type as a two-way interaction, and Drivers (nested within Age) as a random effects when Reflective Level is fixed at High. Table 133 shows that there is a significant interaction effect between Age and Reflectivity Type at α=0.05, which suggests that the effect of Reflectivity Type of high reflective level regulatory signs on Number of Glances is different for Young and Old drivers. The Age*Reflectivity Type interaction plot is also contained in Table 133.

Table 133. Effect of Reflectivity Type on Number of Glances for High Reflective Level Regulatory Signs.

Response Number of Glances (within 40LI) Reflective Level=High, Course Type=Closed

Summary of Fit

RSquare	0.607919
RSquare Adj	0.568711
Root Mean Square Error	0.599102
Mean of Response	1.323529
Observations (or Sum Wgts)	34

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age	1	1	17.29	0.0161	0.9006
Reflectivity Type	1	1	15.63	0.0414	0.8413
Age*Reflectivity Type	1	1	15.63	5.1107	0.0384

Least Squares Means Table

Level	Least Sq Mean	Std Error
Old,II	1.0951501	0.26935746
Old,RS	1.6204221	0.26935746
Young,II	1.5384898	0.26873470
Young,RS	1.1000000	0.24156101

LS Means Plot

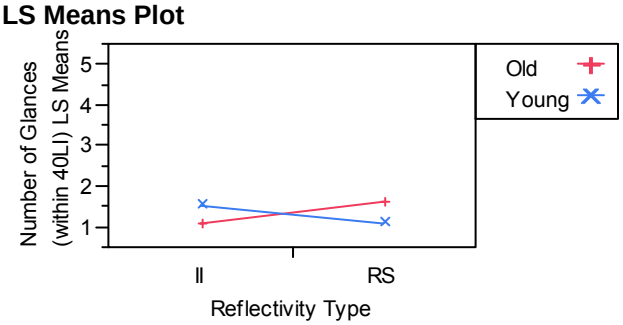


Table 134 shows that there is a significant interaction effect between Age and Reflectivity Type at α=0.05, which suggests that the effect of Reflectivity Type of high reflective level regulatory signs on Leg. Glance Duration is different for Young and Old drivers. The Age*Reflectivity Type interaction plot is also contained in Table 134, which shows that II leads to a smaller Leg. Glance Duration (compared to RS) for young drivers but not for old drivers. The multiple comparison test results are also provided in Table 134.

Table 134. Effect of Reflectivity Type on Leg. Glance Duration for High Reflective Level Regulatory Signs.

Response Leg Glance Duration Reflective Level=High, Course Type=Closed

Summary of Fit

RSquare	0.719529
RSquare Adj	0.691482
Root Mean Square Error	1.522459
Mean of Response	2.902941
Observations (or Sum Wgts)	34

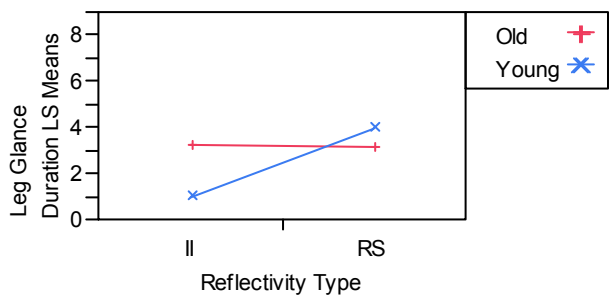
Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age	1	1	14.2	0.8055	0.3844
Reflectivity Type	1	1	12.17	6.9820	0.0213
Age*Reflectivity Type	1	1	12.17	7.8457	0.0158

Least Squares Means Table

Level	Least Sq Mean	Std Error
Old,II	3.2592947	0.74167952
Old,RS	3.1724802	0.74167952
Young,II	0.9517756	0.73796303
Young,RS	3.9300000	0.66721965

LS Means Plot



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α=0.050

Level			Least Sq Mean
Young,RS	A		3.9300000
Old,II	A		3.2592947
Old,RS	A		3.1724802
Young,II		B	0.9517756

Levels not connected by same letter are significantly different.

There were only eight observations for Avg. Glance Duration W/O Leg. (sec), and a reasonable model could not be fitted due to an extremely low sample size. Table 135 shows the model fit with Age and Reflectivity Type as main factors, Age*Reflectivity Type as a two-way interaction, and Drivers (nested within Age) as a random effects fitted to Total Glance Duration for high reflective level regulatory signs. None of the effects were significant at α=0.05.

Table 135. Effect of Reflectivity Type on Total Glance Duration for High Reflective Level Regulatory Signs.

Response Total Glance Duration Reflective Level=High, Course Type=Closed

Summary of Fit

RSquare	0.743099
RSquare Adj	0.717409
Root Mean Square Error	1.477636
Mean of Response	3.514706
Observations (or Sum Wgts)	34

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age	1	1	15.66	0.0745	0.7885
Reflectivity Type	1	1	13.21	1.7284	0.2110
Age*Reflectivity Type	1	1	13.21	0.9273	0.3529

Table 136 shows the model with Age and Reflectivity Type as main factors, Age*Reflectivity Type as a two-way interaction, and Drivers (nested within Age) as random effects fitted to Legibility Glance Start Distance (ft) for high reflective level regulatory signs. There is a significant interaction effect between Age and Reflectivity Type at α=0.05, which suggests that the effect of Reflectivity Type of High reflective level regulatory sign on Legibility Glance Start Distance (ft) is different for Young and Old drivers. The Age*Reflectivity Type interaction plot is also contained in Table 136, which shows that II leads to a smaller Legibility Glance Start Distance (compared to RS) for young drivers but not for old drivers. The multiple comparison test results are also provided in Table 136.

Table 136. Effect of Reflectivity Type on Legibility Glance Start Distance (ft) for High Reflective Level Regulatory Signs.

Response Legibility Glance Start Distance (ft) Reflective Level=High, Course Type=Closed

Summary of Fit

RSquare	0.798838
RSquare Adj	0.778721
Root Mean Square Error	99.88526
Mean of Response	362.8114
Observations (or Sum Wgts)	34

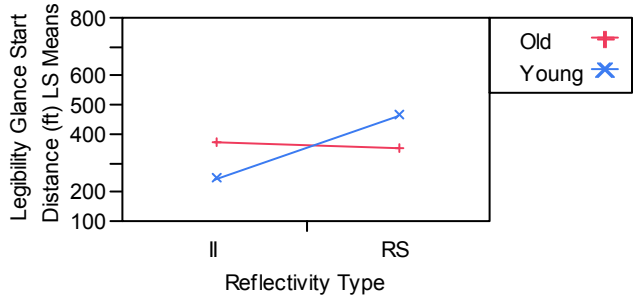
Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age	1	1	15.04	0.0243	0.8782
Reflectivity Type	1	1	12.51	7.3124	0.0186
Age*Reflectivity Type	1	1	12.51	10.6261	0.0065

Least Squares Means Table

Level	Least Sq Mean	Std Error
Old,II	372.29004	54.773011
Old,RS	352.25189	54.773011
Young,II	244.39058	54.050993
Young,RS	459.47426	49.755045

LS Means Plot



LSMeans Differences Student's t

α=0.050

Level			Least Sq Mean
Young,RS	A		459.47426
Old,II	A	B	372.29004
Old,RS	A	B	352.25189
Young,II		B	244.39058

Levels not connected by same letter are significantly different.

Analysis for Regulatory Signs Tested with High Headlight Beams (Speed Limit Signs)

Signs numbered 5, 6, 7, and 9 are analyzed here. These regulatory signs were tested with Course Type=Closed, Course Setting = Rural, Reflectivity Type = Reflective Sheeting, and Letter Height = 10. Reflective Level has two levels: High (corresponding to Signs 5 and 9) and Medium (corresponding to Signs 6 and 7) in this experiment. Researchers were interested in testing whether there is a significant difference between High and Medium reflective levels under high beam headlight illumination. A split-plot model with Age and Reflective Level as main effects, Age*Reflective Level as a two-way interaction, and Driver nested within Age as a

random effect is fitted to each of five response variables for reflective sheeting regulatory signs tested with high headlight beams. Table 137 shows that none of the effects on Number of Glances were significant at α=0.05.

Table 137. Effect of Reflective Level on Number of Glances for Reflective Sheeting Regulatory Signs Tested with High Headlight Beams.

Response Number of Glances (within 40LI)
Summary of Fit

RSquare	0.658235
RSquare Adj	0.640557
Root Mean Square Error	0.614169
Mean of Response	1.564516
Observations (or Sum Wgts)	62

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age	1	1	17.6	0.4197	0.5254
Reflective Level	1	1	42.29	1.3597	0.2501
Age*Reflective Level	1	1	42.29	0.2356	0.6299

Table 138 shows that the effect of Reflective Level on Leg Glance Duration was significant at α=0.05, suggesting that high Reflective Level leads to longer Leg Glance Duration.

Table 138. Effect of Reflective Level on Leg Glance Duration for Reflective Sheeting Regulatory Signs Tested with High Headlight Beams.

Response Leg Glance Duration
Summary of Fit

RSquare	0.405669
RSquare Adj	0.374928
Root Mean Square Error	1.698265
Mean of Response	2.672581
Observations (or Sum Wgts)	62

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age	1	1	16.53	0.3353	0.5704
Reflective Level	1	1	42.37	6.0686	0.0179
Age*Reflective Level	1	1	42.37	0.0563	0.8136

Effect Details

Reflective Level
Least Squares Means Table

Level	Least Sq Mean	Std Error
Medium	2.1897808	0.36324982
High	3.2759330	0.39848536

LS Means Plot

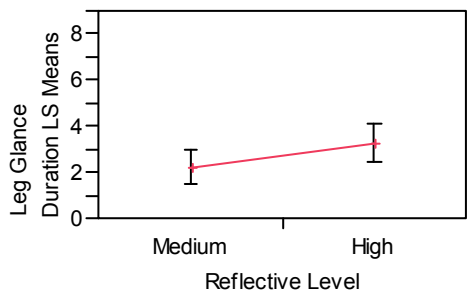


Table 139 shows that there is a significant interaction effect between Reflective Level and Age on Avg. Glance Duration W/O Leg at α=0.05, suggesting that the effect of Reflective Level is different between old and young drivers. The interaction plot indicates that high Reflective Level leads to longer Avg. Glance Duration W/O Leg for older drivers but not for young drivers.

Table 139. Effect of Reflective Level on Avg. Glance Duration W/O Leg for Reflective Sheeting Regulatory Signs Tested with High Headlight Beams.

Response Avg. Glance Duration W/O Leg_

Summary of Fit

RSquare	0.730559
RSquare Adj	0.688016
Root Mean Square Error	0.64262
Mean of Response	1.704348
Observations (or Sum Wgts)	23

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age	1	1	7.4	0.0169	0.8999
Reflective Level	1	1	12.23	3.6853	0.0785
Age*Reflective Level	1	1	12.23	5.6137	0.0351

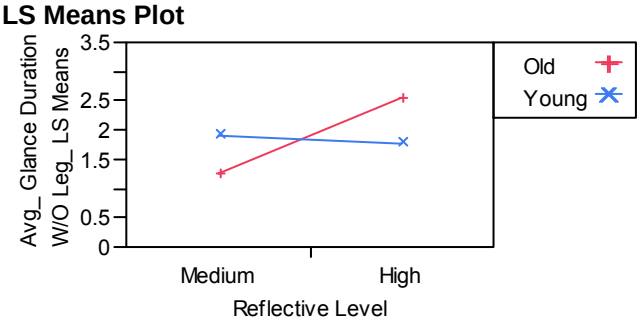
Effect Details

Age*Reflective Level

Least Squares Means Table

Level	Least Sq Mean	Std Error
Old,Medium	1.2734325	0.38481683
Old,High	2.5523649	0.45998533
Young,Medium	1.9090664	0.43001473
Young,High	1.7750000	0.47564888

LS Means Plot



LSMeans Differences Tukey HSD

α=0.050

Level			Least Sq Mean
Old,High	A		2.5523649
Young,Medium	A	B	1.9090664
Young,High	A	B	1.7750000
Old,Medium		B	1.2734325

Levels not connected by same letter are significantly different.

Table 140 shows that there is a significant effect of Reflective Level on Total Glance Duration at α=0.05, which suggests that high Reflective Level leads to longer Total Glance Duration than medium Reflective Level does.

Table 140. Effect of Reflective Level on Total Glance Duration for Reflective Sheeting Regulatory Signs Tested with High Headlight Beams.

Response Total Glance Duration
Summary of Fit

RSquare	0.24682
RSquare Adj	0.207862
Root Mean Square Error	1.802858
Mean of Response	3.304839
Observations (or Sum Wgts)	62

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age	1	1	14.93	0.4104	0.5315
Reflective Level	1	1	41.76	5.6449	0.0222
Age*Reflective Level	1	1	41.76	0.0224	0.8818

Effect Details

Reflective Level
Least Squares Means Table

Level	Least Sq Mean	Std Error
Medium	2.8047599	0.33735435
High	3.9139110	0.37908950

LS Means Plot

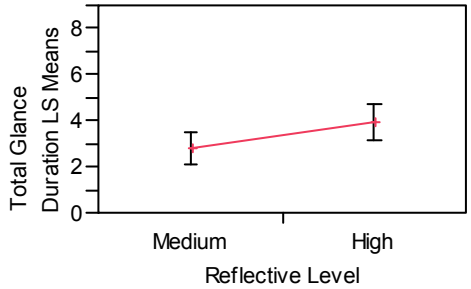


Table 141 shows that there is a significant effect of Reflective Level on Legibility Glance Start Distance (ft) at α=0.05, which suggests that high Reflective Level leads to longer Legibility Glance Start Distance than medium Reflective Level does.

Table 141. Effect of Reflective Level on Legibility Glance Start Distance (ft) for Reflective Sheeting Regulatory Signs Tested with High Headlight Beams.

Response Legibility Glance Start Distance (ft)
Summary of Fit

RSquare	0.210375
RSquare Adj	0.169533
Root Mean Square Error	282.4187
Mean of Response	516.297
Observations (or Sum Wgts)	62

Fixed Effect Tests

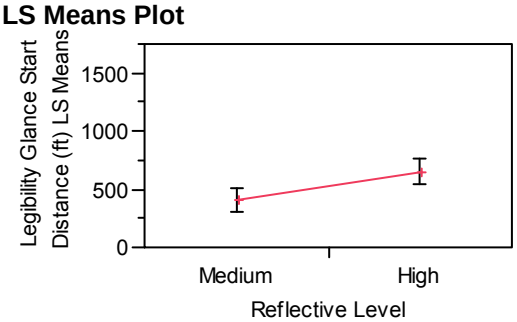
Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age	1	1	17.05	0.2645	0.6136
Reflective Level	1	1	44.53	10.3800	0.0024
Age*Reflective Level	1	1	44.53	0.0813	0.7769

Effect Details

Reflective Level
Least Squares Means Table

Level	Least Sq Mean	Std Error
Medium	414.19296	49.447369
High	649.01559	56.245883

LS Means Plot



Analysis for Guide Sign

Guide signs were tested only on the open course with two course setting levels (Rural and Urban). A split-plot model with Age, Reflective Level, and Course Setting as main effects, Age*Reflective Level and Course Setting *Reflective Level as two-way interactions, and Driver nested within Age as a random effect is employed for guide signs. Tables 142–145 contain the results of running the Guide Sign model .

Table 142 shows that there is a significant interaction effect between Reflective Level and Age on Number of Glances at α=0.05, which suggests that the effect of Reflective Level of Guide signs on Number of Glances is somewhat different for different age groups. It seems that Reflective Level does not make a significant difference in Number of Glances for young drivers,

but for old drivers high reflective level leads to a smaller number of glances compared to low and medium reflective levels.

Table 142. Effect of Reflective Level on Number of Glances for Guide Signs.

Response Number of Glances (within 40LI)
Summary of Fit

RSquare	0.627375
RSquare Adj	0.534218
Root Mean Square Error	0.291528
Mean of Response	1.170732
Observations (or Sum Wgts)	41

PFixed Effect Tests

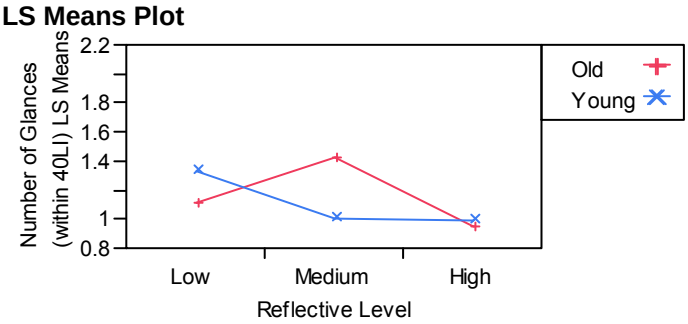
Source	Nparm	DF	DFDen	F Ratio	Prob > F
Course Setting	1	1	20.53	2.6705	0.1175
Reflective Level	2	2	23.1	2.3182	0.1209
Age	1	1	15.18	0.2202	0.6455
Reflective Level*Course Setting	2	2	31.69	1.1836	0.3194
Age*Reflective Level	2	2	21.36	3.9937	0.0336

Effect Details

Age*Reflective Level
Least Squares Means Table

Level	Least Sq Mean	Std Error
Old,Low	1.1131172	0.14339848
Old,Medium	1.4292966	0.12977844
Old,High	0.9511530	0.13567627
Young,Low	1.3311664	0.13584036
Young,Medium	0.9992382	0.14442969
Young,High	0.9837918	0.14314976

LS Means Plot



LSMeans Differences Student's t
α=0.050

Level			Least Sq Mean
Old,Medium	A		1.4292966
Young,Low	A	B	1.3311664
Old,Low	A	B	1.1131172
Young,Medium		B	0.9992382
Young,High		B	0.9837918
Old,High		B	0.9511530

Levels not connected by same letter are significantly different.

Table 143 shows that for Leg. Glance Duration, none of Age, Reflective Level, Course Setting, Age*Reflective Level, and Course Setting *Reflective Level effects, were significant at α=0.05.

Table 143. Effect of Reflective Level on Leg Glance Duration for Guide Signs.

Response Leg Glance Duration
Summary of Fit

RSquare	0.818561
RSquare Adj	0.773201
Root Mean Square Error	1.196574
Mean of Response	3.273171
Observations (or Sum Wgts)	41

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Course Setting	1	1	18.4	17.5569	0.0005
Reflective Level	2	2	20.05	0.6274	0.5441
Age	1	1	16.29	1.0345	0.3240
Reflective Level*Course Setting	2	2	27.27	1.3581	0.2740
Age*Reflective Level	2	2	19.19	1.8924	0.1778

There were only seven observations for Avg. Glance Duration W/O Leg. (sec). Due to the extremely small sample size, a reasonable model could not be fitted. Table 144 shows that none of Age, Reflective Level, Course Setting, Age*Reflective Level, and Course Setting *Reflective Level effects were significant at α=0.05 for Total Glance Duration within 40LI for Guide signs.

Table 144. Effect of Reflective Level on Total Glance Duration within 40LI for Guide Signs.

Response Total Glance Duration
Summary of Fit

RSquare	0.818318
RSquare Adj	0.772897
Root Mean Square Error	1.105685
Mean of Response	3.521951
Observations (or Sum Wgts)	41

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Course Setting	1	1	18.37	13.0772	0.0019
Reflective Level	2	2	19.94	1.6741	0.2128
Age	1	1	16.47	1.4143	0.2512
Reflective Level*Course Setting	2	2	26.87	1.3855	0.2675
Age*Reflective Level	2	2	19.14	0.6725	0.5221

Table 145 shows that none of Age, Reflective Level, Course Setting, Age*Reflective Level, and Course Setting *Reflective Level effects were significant at α=0.05 for Legibility

Glance Start Distance for Guide signs although the interaction effect Age*Reflective Level were significant at α=0.1. The interaction plot was provided for information purposes.

Table 145. Effect of Reflective Level on Legibility Glance Start Distance for Guide Signs.

Response Legibility Glance Start Distance (ft)
Summary of Fit

RSquare	0.831499
RSquare Adj	0.789373
Root Mean Square Error	99.62
Mean of Response	440.5995
Observations (or Sum Wgts)	41

Fixed Effect Tests

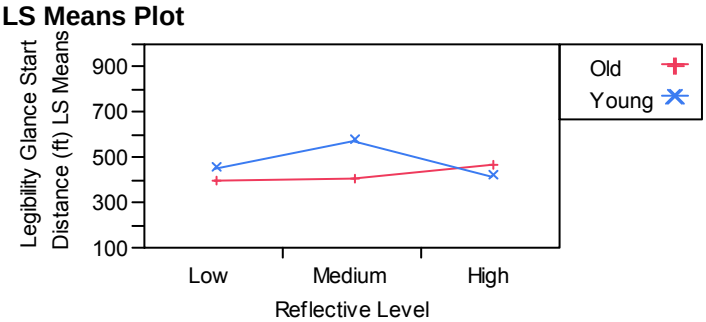
Source	Nparm	DF	DFDen	F Ratio	Prob > F
Course Setting	1	1	16.47	2.2237	0.1548
Reflective Level	2	2	17.69	0.9526	0.4047
Age	1	1	15.61	0.5990	0.4505
Reflective Level*Course Setting	2	2	23.41	0.1045	0.9012
Age*Reflective Level	2	2	17.16	3.0567	0.0732

Effect Details

Age*Reflective Level
Least Squares Means Table

Level	Least Sq Mean	Std Error
Old,Low	399.04151	65.057633
Old,Medium	408.02541	60.608262
Old,High	468.15584	61.423968
Young,Low	453.37325	60.638618
Young,Medium	570.27364	63.800443
Young,High	414.76732	63.022399

LS Means Plot



Analysis for Street Name Sign

Street name signs were all reflective sheeting signs and tested only on the open course with two course setting levels (Rural and Urban). A split-plot model with Age, Reflective Level, and Course Setting as main effects, and Age*Reflective Level and Course Setting*Reflective Level as two-way interactions, and Driver nested within Age as a random effect is employed for street name signs. Tables 146–149 contain the results.

Table 146 shows that none of Age, Reflective Level, Course Setting, Age*Reflective Level, and Course Setting *Reflective Level effects were significant at α=0.05 for Number of Glances for Street name signs although the effect of Reflective Level was significant at α=0.1. The Least Squares Means table and LS means plot were provided for information purposes.

Table 146. Effect of Reflective Level on Number of Glances for Street Name Signs.

Response Number of Glances (within 40LI)
Summary of Fit

RSquare	0.504879
RSquare Adj	0.306831
Root Mean Square Error	0.475473
Mean of Response	1.310345
Observations (or Sum Wgts)	29

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age	1	1	8.839	0.2937	0.6012
Reflective Level	2	2	16.14	2.7134	0.0964
Course Setting	1	1	8.481	2.5660	0.1457
Age*Reflective Level	2	2	13.06	0.7165	0.5067
Reflective Level*Course Setting	2	2	14.59	1.4163	0.2741

Effect Details

Reflective Level
Least Squares Means Table

Level	Least Sq Mean	Std Error
Low	1.3100282	0.17827708
Medium	1.6625850	0.18898657
High	1.0918647	0.16596070

LS Means Plot

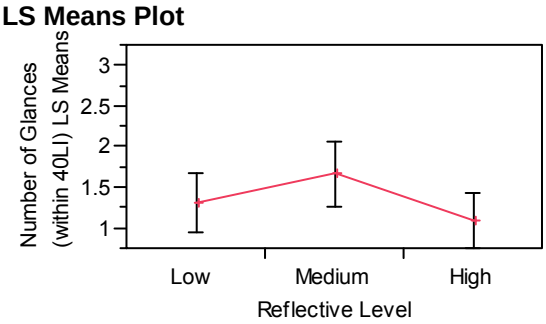


Table 147 shows that there is a significant interaction effect between Reflective Level and Course Setting at α=0.05, which suggests that the effect of Reflective Level of street name signs on Leg. Glance Duration is different for Rural and Urban course settings. The Reflective Level*Course Setting interaction plot is also contained in Table 147, which indicates that Leg. Glance Duration for high reflective level leads to significantly longer Leg Glance Duration for rural course setting than for urban course setting while the other reflective levels do not make any

significance difference in Leg. Glance Duration between rural and urban course setting. The multiple comparison test results are also provided in Table 147.

Table 147. Effect of Reflective Level on Leg Glance Duration for Street Name Signs.

Response Leg Glance Duration
Summary of Fit

RSquare	0.507598
RSquare Adj	0.310637
Root Mean Square Error	0.973437
Mean of Response	1.834483
Observations (or Sum Wgts)	29

Fixed Effect Tests

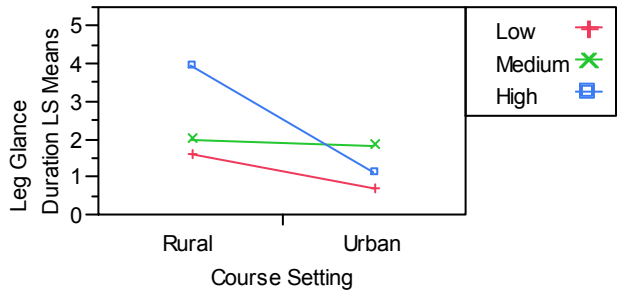
Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age	1	1	11.9	1.7357	0.2125
Reflective Level	2	2	16.97	4.8472	0.0216
Course Setting	1	1	12.5	10.1765	0.0074
Age*Reflective Level	2	2	17.59	0.0917	0.9128
Reflective Level*Course Setting	2	2	17.69	5.0249	0.0187

Effect Details

Reflective Level*Course Setting
Least Squares Means Table

Level	Least Sq Mean	Std Error
Low,Rural	1.5767682	0.37685653
Low,Urban	0.7185678	0.55424118
Medium,Rural	1.9500000	0.46141874
Medium,Urban	1.8141145	0.50394763
High,Rural	3.9513152	0.46838397
High,Urban	1.1344301	0.37277184

LS Means Plot



LSMeans Differences Tukey HSD
α=0.050

Level			Least Sq Mean
High,Rural	A		3.9513152
Medium,Rural	A	B	1.9500000
Medium,Urban	A	B	1.8141145
Low,Rural		B	1.5767682
High,Urban		B	1.1344301
Low,Urban		B	0.7185678

Levels not connected by same letter are significantly different.

No reasonable model could be fitted to Avg. Glance Duration W/O Leg. (sec) due to an extremely small sample size (n= 8). Table 148 shows that there is a significant interaction effect

between Reflective Level and Course Setting at α=0.05, which suggests that the effect of Reflective Level of street name signs on Total Glance Duration is different for Rural and Urban course settings. The Reflective Level*Course Setting interaction plot is also contained in Table 148, which indicates that Total Glance Duration for high reflective level leads to significantly longer Total Glance Duration for rural course setting than for urban course setting while the other reflective levels do not make any significance difference in Leg. Glance Duration between rural and urban course setting. The multiple comparison test results are also provided in Table 148.

Table 148. Effect of Reflective Level on Total Glance Duration for Street Name Signs.

Response Total Glance Duration
Summary of Fit

RSquare	0.476869
RSquare Adj	0.267617
Root Mean Square Error	0.973132
Mean of Response	2.127586
Observations (or Sum Wgts)	29

Fixed Effect Tests

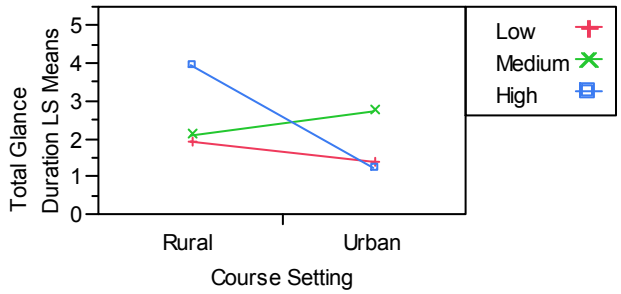
Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age	1	1	11.44	0.9323	0.3542
Reflective Level	2	2	16.83	2.3469	0.1262
Course Setting	1	1	11.89	4.6657	0.0519
Age*Reflective Level	2	2	17.04	0.2410	0.7884
Reflective Level*Course Setting	2	2	17.31	7.1860	0.0053

Effect Details

Reflective Level*Course Setting
Least Squares Means Table

Level	Least Sq Mean	Std Error
Low,Rural	1.9230615	0.38357818
Low,Urban	1.3920506	0.56571187
Medium,Rural	2.0750000	0.46927836
Medium,Urban	2.7258498	0.51447979
High,Rural	3.9658656	0.47762629
High,Urban	1.2522689	0.37931479

LS Means Plot



LSMeans Differences Tukey HSD
α=0.050

Level			Least Sq Mean
High,Rural	A		3.9658656
Medium,Urban	A	B	2.7258498
Medium,Rural	A	B	2.0750000
Low,Rural		B	1.9230615
Low,Urban		B	1.3920506
High,Urban		B	1.2522689

Levels not connected by same letter are significantly different.

Table 149 shows that the effect of Course Setting on Legibility Glance Start Distance was significant at α=0.05, which suggests that Legibility glance Start Distance is longer under rural course setting than under urban course setting.

Table 149. Effect of Reflective Level on Legibility Glance Start Distance for Street Name Signs.

Response Legibility Glance Start Distance (ft)
Summary of Fit

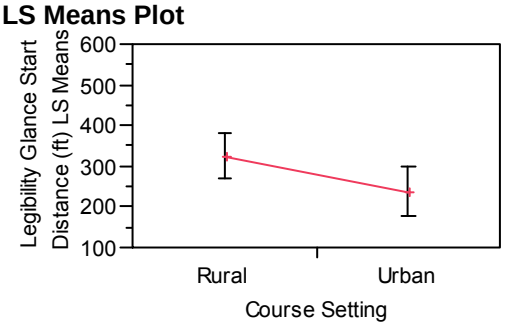
RSquare	0.636918
RSquare Adj	0.491685
Root Mean Square Error	88.09391
Mean of Response	282.3946
Observations (or Sum Wgts)	29

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Age	1	1	10.62	6.1665	0.0311
Reflective Level	2	2	17.51	1.0713	0.3640
Course Setting	1	1	9.922	5.3858	0.0429
Age*Reflective Level	2	2	13.76	0.1068	0.8994
Reflective Level*Course Setting	2	2	15.47	0.2833	0.7571

Effect Details

Course Setting
Least Squares Means Table

Level	Least Sq Mean	Std Error
Rural	324.20205	26.817846
Urban	237.47859	29.465197

LS Means Plot