TASK 4:
DATA ANALYSIS

ASSUMPTIONS AND DELETIONS

- ***Font Type.*** Font types studied included the following, along with their associated abbreviations used throughout this report:
  Clearview 5W (C)
  Series E-Mod (E)
  Enhanced E-Mod (S)
- ***Incorrect Responses.*** Each word or number used in the study has a chance to be read incorrectly, though some words or numbers have a tendency to be read incorrectly more often. Analysis showed that the difference among the words or numbers that were read incorrectly is not significant, which indicates it is reasonable to assume that all words or numbers are equivalent to participants. Therefore, all words and numbers were included in the analysis.

Table 1. Number of incorrect responses by legend and font type. (Note: The three legends most often read incorrectly are shown in red.)

Legend	Font			Total
	C	E	S	
31	2	0	3	5
38	2	0	3	5
52	1	1	0	2
73	2	3	5	10
85	4	0	8	12
Buffer	2	10	7	19
Dishes	0	1	3	4
Finish	2	0	3	5
Grapes	0	0	1	1
Honors	3	2	2	7
Houses	7	1	1	9
Hungry	0	3	0	3
Jogger	0	9	5	14
Orange	0	5	1	6
Punish	0	0	2	2
Rubber	1	0	2	3
Season	1	4	1	6
Sensor	3	1	1	5
Series	5	2	1	8
Supper	7	3	11	21
Total	42	45	60	147

- ***Incomplete Data.*** Data records for Participant #51 (participants were numbered in the study) are incomplete, so they were deleted from the dataset.

- ***Outliers.*** The Legibility Index (LI) is the distance at which a sign can be read (legibility distance) divided by the character height. Participant #71 has the lowest mean value of LI (13.6); participants #2 and #4 have the highest mean LI, both larger than 65. (Figure 1) These three participants are considered as outliers and were deleted from the dataset for analysis.

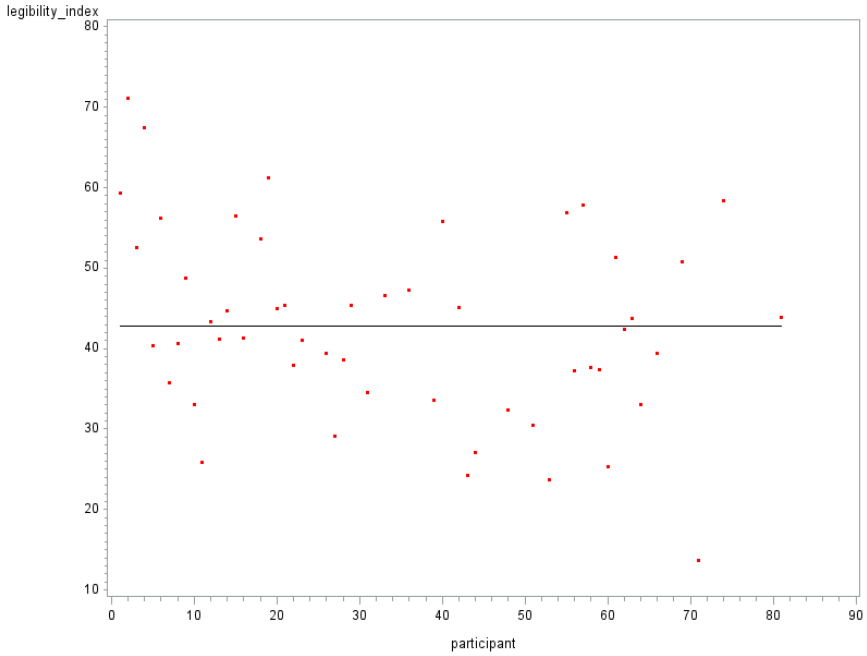

Figure 1. Legibility index by participant number.

- ***Effect of Learning Curve.*** Subjects who participated in both day and night runs (12 total) had a slightly lower mean LI than subjects who only participated in the night study. However, the difference is not significant, which indicates that the learning effect can be disregarded and all nighttime data can be combined. (See Table 2 and Figure 2)

Table 2. Effect of driver learning curve for both daytime and nighttime driving versus nighttime driving only participants.

	Nighttime Legibility Index	
	Both Daytime and Nighttime Drivers (Number of observations = 220)	Nighttime Only Drivers (Number of observations = 670)
Mean	41.5	41.7
Lower 95% CL	40.0	40.8
Upper 95% CL	43.0	42.6

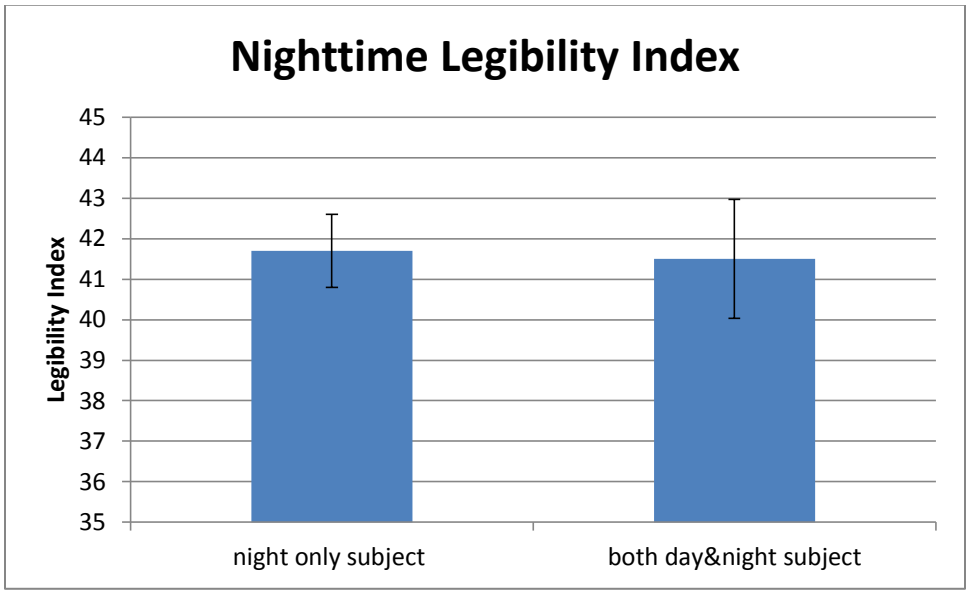

Figure 2. Nighttime legibility index for nighttime only drivers versus both daytime and nighttime drivers.

PARTICIPANT DEMOGRAPHICS

Care was taken during recruiting of participants to ensure balance among age groups and gender tested. Researchers sought to test equal numbers of males and females for both daytime and nighttime driving conditions. Also, because the focus of this study is on older drivers during nighttime driving, researchers sought to test twice as many older drivers as younger drivers, again balancing for gender.

Unfortunately, poor weather conditions caused testing to be delayed repeatedly, with the original 3-week testing period extending into 7 weeks. The need to reschedule participants resulted in slight changes to the demographics of participants who actually participated in the study. However, every effort was made to maintain the original demographic balance. Also, as previously mentioned, data for 4 participants was omitted, 1 due to incomplete data and 3 that were considered outliers. The resulting participant demographics are presented in Table 3.

Table 3. Demographics of participants included in the data analysis.

Age Group	Daytime		Nighttime		Totals
	Male	Female	Male	Female	
21-35	4	2	6	10	22
65+	3	6	14	15	38
Totals	**7**	**8**	**20**	**25**	**60**

Number of Data Points Evaluated

Gender

- Female 615 data points (52.6%)
- Male 554 data points (47.4%)

Age

- Young 394 data points (33.7%)
- Old 775 data points (66.3%)

FINDINGS

Daytime vs. Nighttime Driving

A basic analysis was initially done to compare legibility index during the daytime and nighttime driving conditions for all participants combined. As expected, legibility index for daytime driving was significantly larger than for nighttime driving, with mean values of 48.3 and 41.5 for daytime and nighttime conditions, respectively. (Table 4)

Table 4. Legibility index for daytime and nighttime driving conditions for all participants combined.

	Legibility Index	
	Day (N=219)	**Night (N=221)**
Mean	48.3	41.5
Lower 95% CL	46.7	40.0
Upper 95% CL	49.8	43.0

Daytime Driving

An Analysis of variance (ANOVA) for daytime data shows that age group is the only variable that is statistically significant to legibility index with the significance level at 0.05. (Note, all statistical significance in this report refer to findings with a significance level of 0.05, if not otherwise specified.) Font type and legend type do not significantly affect legibility index. (Table 5)

Table 5. ANOVA for legibility index by age, font type, and legend type for daytime driving conditions.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Age_Group	1	1924.440706	1924.440706	14.17	0.0002
Font	2	359.405723	179.702862	1.32	0.2682
Legend_Type	3	105.694714	35.231571	0.26	0.8546
Age_Group*Font	2	218.727654	109.363827	0.81	0.4482
Age_Group*Legend_Type	3	114.719105	38.239702	0.28	0.8387
Font*Legend_Type	6	1201.894331	200.315722	1.47	0.1872
Age_Group*Font*Legend_Type	6	655.457068	109.242845	0.80	0.5675

Further analysis applying a least squares comparison (Tukey-Kramer) shows, not surprisingly, that younger drivers had a significantly larger legibility index than older drivers under daytime driving conditions. Mean legibility index for younger and older drivers were 52.17 and 45.63, respectively. (Table 6)

Table 6. Least squares means analysis by age group under daytime driving conditions. (Least square means adjustment for multiple comparisons: Tukey-Kramer.)

Age_Group	Legibility_Index LSMEAN	H0:LSMean1=LSMean2 Pr > |t|
O	45.6258787	0.0002
Y	52.1757498	

Separate ANOVA analyses were conducted for the data of the younger and older driver groups to determine if there were any significant findings within the two groups. ANOVA for younger drivers during daytime driving showed that neither font type nor legend type had significant effects on legibility index. (Table 7)

Table 7. ANOVA for legibility index by font type and legend type for younger drivers under daytime driving conditions.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Font	2	301.885133	150.942567	0.59	0.5591
Legend_Type	3	0.396642	0.132214	0.00	1.0000
Font*Legend_Type	6	1048.013082	174.668847	0.68	0.6673

Similar analysis conducted for older drivers under daytime driving conditions also showed that neither font nor legend type had a significant effect on legibility index. (Table 8)

Table 8. ANOVA for legibility index by font type and legend type for older drivers under daytime driving conditions.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Font	2	258.9087321	129.4543660	1.40	0.2485
Legend_Type	3	446.4228558	148.8076186	1.61	0.1880
Font*Legend_Type	6	725.3590498	120.8931750	1.31	0.2547

Halation Effects (Nighttime Driving)

Because the focus of this study concerns the halation effects of sign sheeting during nighttime driving and its effect on various fonts, the majority of the analysis focused on nighttime driving data, especially among older drivers. Factors evaluated include not only participant age and font type but also legend type. Legend type categories included words with ascenders (A), words with descenders (D), neutral words with neither ascenders nor descenders (N), and numbers (#).

When evaluating legibility index by age, font type, and legend type, ANOVA results showed that font type was not significant for legibility index during nighttime driving conditions. However, age group and legend type were significant. (Table 9)

Table 9. ANOVA for legibility index by age, font type, and legend type for nighttime driving conditions.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Age_Group	1	22675.22550	22675.22550	212.27	<.0001
Font	2	277.06456	138.53228	1.30	0.2739
Legend_Type	3	2138.41641	712.80547	6.67	0.0002
Age_Group*Font	2	104.51325	52.25662	0.49	0.6133
Age_Group*Legend_Type	3	171.38401	57.12800	0.53	0.6585
Font*Legend_Type	6	1190.68659	198.44777	1.86	0.0853
Age_Group*Font*Legend_Type	6	288.91743	48.15291	0.45	0.8447

Figure 3 shows mean legibility index with confidence intervals by font type and legend type for all participants.

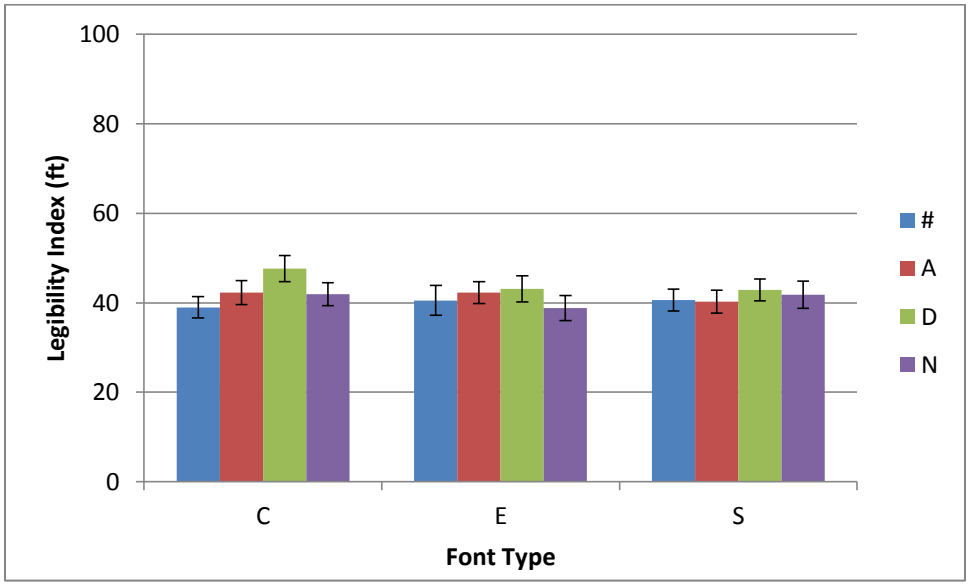

Figure 3. Legibility index by font type and legend type for all participants.

Further analysis applying a least squares comparison (Tukey-Kramer) shows, not surprisingly, that for nighttime driving, younger drivers had a significantly larger legibility index than older drivers. (Table 10)

Table 10. Least squares means analysis by age group under nighttime driving conditions (Least square means adjustment for multiple comparisons: Tukey-Kramer.)

Age_Group	Legibility_Index LSMEAN	H0:LSMean1=LSMean2 Pr > |t|
O	37.9141827	<.0001
Y	48.8036748	

Figures 4 and 5 show the legibility index by font type and legend type for younger drivers and older drivers, respectively.

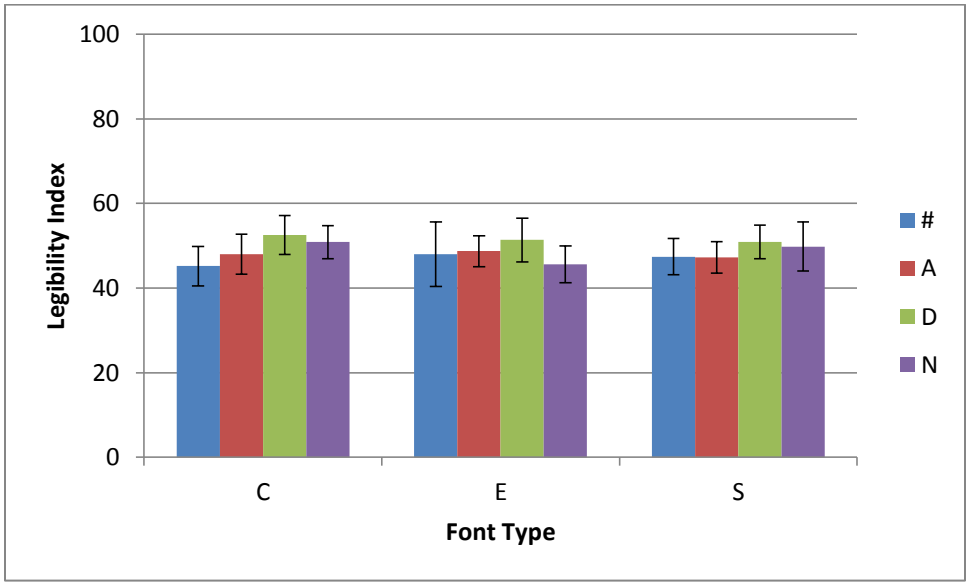

Figure 4. Legibility index by font type and legend type for younger participants.

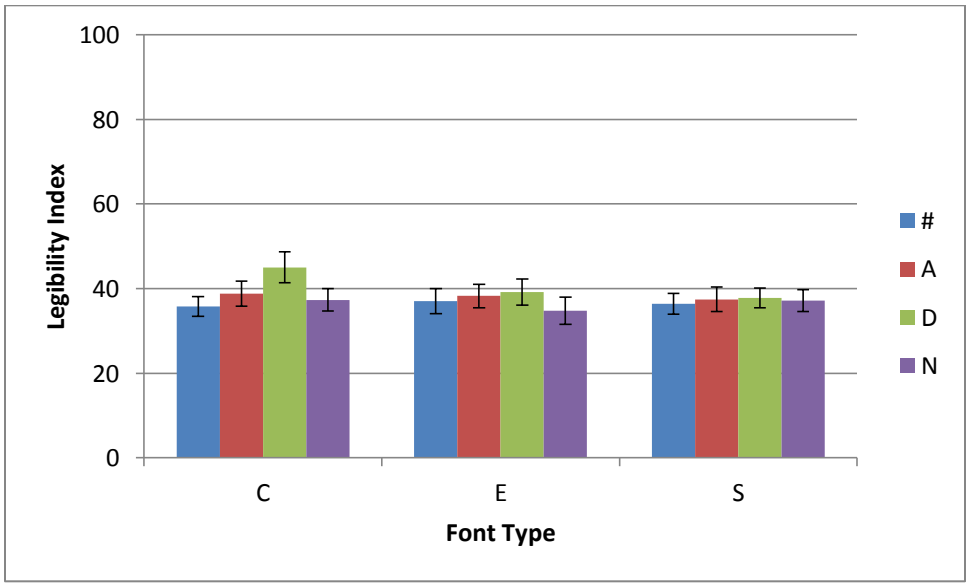

Figure 5. Legibility index by font type and legend type for older participants.

Further analysis was conducted to determine if there were any significant findings within the younger and older driver groups. ANOVA for younger drivers during nighttime driving showed that neither font nor legend type had a significant effect on legibility index. (Table 11)

Table 11. ANOVA for legibility index by font type and legend type for younger drivers.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Font	2	25.4057261	12.7028630	0.10	0.9076
Legend_Type	3	878.6586510	292.8862170	2.24	0.0840
Font*Legend_Type	6	553.3807357	92.2301226	0.70	0.6463

A similar analysis for older drivers showed that, similar to younger drivers, font type did not have a significant effect on legibility index. However, legend type was significant. (Table 12)

Table 12. ANOVA for legibility index by font type and legend type for older drivers.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Font	2	496.928364	248.464182	2.65	0.0717
Legend_Type	3	1658.907083	552.969028	5.89	0.0006
Font*Legend_Type	6	1070.105948	178.350991	1.90	0.0788

Furthermore, multiple comparisons for the effect of legend type on legibility distance for older drivers showed that descending legends had a significantly larger legibility index than numbers and neutral legends for the combination of font and legend type. (Tables 13 and 14)

Table 13. Least squares means analysis by legend type for older drivers under nighttime driving conditions. (Least square means adjustment for multiple comparisons: Tukey-Kramer)

Legend_Type	Legibility_Index LSMEAN	LSMEAN Number
#	36.4079897	1
A	38.1844985	2
D	40.6567542	3
N	36.4074883	4

Table 14. Least squares means analysis for effect of legend type for older drivers under nighttime driving conditions.

Least Squares Means for effect Legend_Type Pr > |t| for H0: LSMean(i)=LSMean(j) Dependent Variable: Legibility_Index				
i/j	**1**	**2**	**3**	**4**
1		0.4262	0.0020	1.0000
2	0.4262		0.1399	0.4158
3	0.0020	0.1399		0.0017
4	1.0000	0.4158	0.0017	

Results show that descending legends in Clearview outperformed all other legend/font combinations. In fact, Clearview descending legends had a significantly larger legibility index than numbers and neutral legends for both Clearview and Series E-Mod. Descending legends in Clearview also had a significantly larger legibility index than all legend types for Enhanced E-Mod. Clearview also outperformed ascending and neutral legends of Series E-Mod and Enhanced E-Mod, although these differences were not significant. (Table 15 and Table 16) Interestingly, for the number legends, Series E-Mod had the largest legibility index, followed by Enhanced E-Mod and then Clearview. These differences, however, were not significant. (Table 15 and Table 16)

Table 15. Least squares means analysis for effect of font type and legend type on legibility index for older drivers under nighttime driving conditions.

Font	Legend_Type	Legibility_Index LSMEAN	LSMEAN Number
C	**#**	35.7784771	1
C	**A**	38.8340583	2
C	**D**	45.0334928	3
C	**N**	37.3247151	4
E	**#**	37.0364103	5
E	**A**	38.2661180	6
E	**D**	39.1396191	7
E	**N**	34.7212859	8
S	**#**	36.4090816	9
S	**A**	37.4533192	10
S	**D**	37.7971508	11
S	**N**	37.1764638	12

Table 16. Least squares means analysis for effect of font type and legend type for older drivers under nighttime driving conditions.

Least Squares Means for effect Font*Legend_Type
Pr > |t| for H0: LSMean(i)=LSMean(j)
Dependent Variable: Legibility_Index

i/j	1	2	3	4	5	6	7	8	9	10	11	12
1		0.9132	0.0006	0.9993	1.0000	0.9749	0.8034	1.0000	1.0000	0.9992	0.9939	0.9999
2	0.9132		0.1666	0.9997	0.9998	1.0000	1.0000	0.6919	0.9850	0.9999	1.0000	0.9998
3	0.0006	0.1666		0.0100	0.0448	0.0697	0.1857	0.0002	0.0026	0.0212	0.0269	0.0305
4	0.9993	0.9997	0.0100		1.0000	1.0000	0.9976	0.9699	1.0000	1.0000	1.0000	1.0000
5	1.0000	0.9998	0.0448	1.0000		1.0000	0.9985	0.9975	1.0000	1.0000	1.0000	1.0000
6	0.9749	1.0000	0.0697	1.0000	1.0000		1.0000	0.8336	0.9980	1.0000	1.0000	1.0000
7	0.8034	1.0000	0.1857	0.9976	0.9985	1.0000		0.5240	0.9495	0.9993	0.9999	0.9986
8	1.0000	0.6919	0.0002	0.9699	0.9975	0.8336	0.5240		0.9994	0.9697	0.9151	0.9929
9	1.0000	0.9850	0.0026	1.0000	1.0000	0.9980	0.9495	0.9994		1.0000	0.9998	1.0000
10	0.9992	0.9999	0.0212	1.0000	1.0000	1.0000	0.9993	0.9697	1.0000		1.0000	1.0000
11	0.9939	1.0000	0.0269	1.0000	1.0000	1.0000	0.9999	0.9151	0.9998	1.0000		1.0000
12	0.9999	0.9998	0.0305	1.0000	1.0000	1.0000	0.9986	0.9929	1.0000	1.0000	1.0000	