Traffic Control Devices Pooled Fund Study

Business Logo Signing: An Evaluation of the Number of Logo Panels on Specific Service Signs

Final Report

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INTRODUCTION

BACKGROUND

Specific Service signs are guide signs which provide drivers with business identification and directional information along freeway approaches to interchanges. The term Business Logo signing is also used in reference to the application of particular business logos (or text) from eligible service categories (i.e., gas, food, lodging, camping, attractions and 24-hour pharmacies) to these service signs.

The Manual on Uniform Traffic Control Devices (MUTCD) currently limits the number of Specific Service signs, hereafter referred to as Business Logo signs, along an interchange approach to four, and the number of logo panels per sign to six.[1] As these 24 available logo panels must be shared between the six eligible service categories, there have been continuing requests to state DOTs to increase the number of logo panels that are allowed per sign. As a result, the Federal Highway Administration (FHWA) has allowed some states to increase either the number of signs or number of logo panels per sign along the interchange approach on an experimental basis. Yet, little is known about the research that led to the establishment of the current MUTCD guidelines.

The Traffic Control Devices Pooled Fund Study (TCD PFS) is a continual effort that focuses on a systematic evaluation of novel TCDs that addresses human factors and operations issues for each TCD idea. As part of this effort, the FHWA Human Factors Team is evaluating Business Logo signs to determine if an increase in the number of logo panels per sign effects drivers' ability to safely and effectively identify available service options indicated by the sign.

LITERATURE REVIEW

A large concern behind increasing the number of logo panels is the possibility of information overload. Lerner et al. (2003) discuss guidelines for identifying and preventing Driver Information Overload (DIO) and defines DIO as occurrences "…when the driver cannot process the roadway information in sufficient time to respond properly and safely at the design speed or the 85th percentile operating speed, whichever is higher." (pg. 9). Drivers confronted with information overload may react by reducing speed to allow more time to process the information, thus potentially resulting in traffic slow downs, conflicts, or collisions.[2] DIO is likely to occur in the vicinity of freeway exits[2] which is especially important for Business Logo signs as they are commonly located along the approaches to freeway interchanges. It is possible that DIO may lead to erratic driver behavior such as making a late exit and crossing the exit gore, or backing up on the shoulder to correct an error.[2] Therefore, it is necessary to determine if drivers are able to process the information provided on Business Logo signs within a reasonable amount of time in order to determine if drivers are able to collect the information needed when a larger number of logo panels are present.

Evaluations of Driver Safety

Driver distraction occurs when a driver engages in a secondary task that is not necessary to perform the primary driving task[3], or when inattention leads to a delay in recognition of information necessary to accomplish the driving task[4].

Though visually scanning the driving environment may be an activity that enhances safety, Klauer et al. (2006) determined that this is only the case if the scanning behavior is systematic and the drivers' eyes return to the forward roadway in under 2 seconds. Eye glances away from the forward roadway that are greater than 2 seconds, regardless of the location of the eye glance, increases the relative crash/near-crash risk to over two times the risk of normal, baseline driving. Olson et al. (2009) also found that long eye glance durations away from the forward roadway increase the risk of being involved in a safety critical event. Specifically, it was found that glances greater than 1.5 seconds increase risk to 1.3 times the risk of normal driving Further, glances greater than 2 seconds increase risk to 2.9 times the risk of normal, baseline driving.

In order to evaluate driver safety in regards to Business Logo signs, Carter and Wang (2007) recorded traffic data at 16 locations which each had a six-panel sign, a nine-panel sign, or overflow signs. The researchers examined the video for unusual driving behavior such as braking, drifting in lane, encroaching on lane lines, and encroaching on edge lines. There were no significant differences in observed driving behavior between the three different sign type locations.[5] However, each sign location was viewed for one hour only, and all but one of the locations was viewed only after the installation of nine-panel or overflow signs (i.e., there was no information on driving behavior at these locations prior to the addition of nine-panel or overflow signs). It is unclear whether the reported lack of differences in driving behavior can be directly attributed to the different configurations of Business Logo signs.

Lee et al. (2005) analyzed before-and-after crash rates in order to determine if permitting two Full Service Food (a proposed new service category) logos on another motherboard (e.g. Camping) with vacant space impacted driver distraction. It was hypothesized that this change would be no more distracting to the motorist than a motherboard having combinations of logos such as Camping/Attractions, and consequently that there would be no additional safety risk caused by having more than six Food logos on two sign structures. Records were examined for crashes occurring one year before and one year after installation of the signs at each test site. Crashes occurring from 1,584 ft before the first Business Logo sign for an exit up to the exit were used in the analyses. Results indicated that motorists were confused by the new "Full Service Food" service type meaning; however results indicated that no additional safety risk was found to be caused by having more than six Food logos on two sign structures.[6]

Crash databases have estimated that driver distraction is a primary factor in about 25-30 percent of crashes[7]. It is to be expected that inattention plays a role in roadway crashes; however, crash databases have the potential for recording inaccurate or incomplete information[4] as they are mostly based on police reports, vehicle and crash site investigation, interviews, and reviews of medical records[7]. Additionally, examinations of naturalistic approaches indicate that driver inattention plays a role in 78 percent of light-vehicle crashes[3] and 71 percent of commercial motor vehicle crashes[4], which may be more accurate representations of the impacts of driver

distraction. Therefore, it is difficult to quantify if Business Logo signs result in driver inattention based on crash records alone. There is no research to date on driver eye glance behavior for Business Logo signs, so it remains unclear how long drivers tend to move their eyes away from the forward roadway in order to read these signs.

Evaluations of Sign Effectiveness

Another factor that should be considered when determining the number of logo panels per sign is the efficiency, or the effectiveness, of the sign. In other words, how well drivers can process the content of the sign to identify available options indicated by the sign.

Hummer and Maripalli (2008) sought to determine driver ability to read nine-panel signs compared to reading six-panel or mixed-panel signs (two service categories on one sign). Exposure time to the sign was also examined: 1.0 s to represent a quick scan of the sign while in heavy traffic, 2.5 s to represent a longer look that might occur in light traffic, and a few trials testing a sequence of exposure which included three flashes of 1.0 s each. Participants were given a particular business to search for, shown the sign for a given exposure time, and asked to state whether that business was shown on the sign. Additional factors such as target presence (was target logo present on the sign), familiarity (familiar vs. unfamiliar), position (top, middle, or bottom row), and business type (gas, food, or lodging) were also manipulated. When combining all sign types, the correct responses varied significantly by exposure time, with overall correct response rates of 65%, 81.5%, and 89% for the 1.0 s, sequence flashing, and 2.5 s exposure times, respectively.[8] In other words, as one would expect, longer consistent viewing time resulted in improved accuracy of responses. Six-panel signs had higher correct responses than the other sign types in all three exposure times. Furthermore, participant accuracy for six-panel signs was significantly greater than nine-panel signs at the 1.0 s and 2.5 s exposures. Mixed-panel signs had the lowest correct responses at 2.5 s exposure (85.3%), which was still higher than the sign type performing the best at 1.0 s exposure (six-panel signs; 69.6%). Participants made more errors when the logo they wanted to find was absent than when it was present on the sign (i.e., false alarms), especially with nine-panel signs. There were also more errors when searching for a familiar logo than when searching for an unfamiliar logo. Logo position on the sign made little difference, with only a 3% increase in correct responses for a logo in row 1 or 2 than a logo in row 3, which is not surprising given typical reading patterns (or typical serial search patterns). These results indicate that the amount of time given to view the signs matters a great deal. The researchers also declared that a nine-panel sign is more likely to keep drivers looking away from the relevant roadway longer than a six-panel or mixed-panel sign.

Hawkins and Rose (2005) examined the effects of adding dual-logo panels to Business Logo signs in response to business owners' concern that separate logos do not convey when two brands are combined under the same roof. Signs were examined at three exposure times: 0.8 s, 1.3 s and 1.8 s. Participants were placed into one of two groups; Set A viewed signs at 0.8 s and 1.3 s, and Set B viewed signs at 1.3 s and 1.8 s. Contrary to some of the findings of the previous study, the results showed higher percentages of correct responses for familiar logos than for unfamiliar logos, though this was not a significant difference. However, significant differences in performance between dual and single logos were only found for familiar logos. When collapsing

across familiarity, differences between single and dual logos were only found to be significant at lower exposure times. The percent of correct responses was higher for single logos than for dual logos, with 74%, 75%, 84% and 85% for the exposure times of 0.8 s, 1.3 s (Set A), 1.3 s (Set B), and 1.8 s, respectively.

In a laboratory study evaluating tourist signs in Ontario, Smiley, et al. (1998) had drivers search for destinations to identify presence, direction and distance of their target. While these signs differ from Business Logo signs, the researchers evaluated both the number of destination names per sign, as well as driver ability to recognize the direction of their destination off of an exit, which are similar uses as Business Logo signs. Based on eye glance data, a driver visual acuity of 20/30, legibility distance of 7.5 in letter height, and a driving speed of 50 mph, Smiley et al. identified the available reading time for the signs as 2.5 s and also used a second viewing time of 1.5 s to look at performance under conditions such as heavy traffic or night time driving.[10] For the 2.5 s viewing time, 94% or more of target destinations were correctly recognized, and 79% were correctly recognized for the 1.5 s time. For the lowest load of 3 destination names on the sign, viewed for 2.5 s, about 1 in 16 drivers reported the wrong direction, and increased to 1 in 8 reporting the wrong direction when 4 names and 5 names were shown on the sign. When the presentation time was reduced to 1.5 s, 1 in 6 reported the wrong direction for 3 names, 1 in 4 for 4 names, and 1 in 3 for 5 names. The researchers concluded that 1 in 8 drivers unable to obtain directional information at the longer viewing time is unsatisfactory, and thus recommended that only 3 names be used on each sign.

Summary

Previous research suggests that other factors, such as exposure time and logo familiarity, may have an influence on the effectiveness of the sign rather than number of logo panels alone. However, in the real world, driver familiarity with business logos cannot be controlled. Therefore, the present research sought to evaluate the signs in a manner representative of what drivers are likely to experience in the real world.

The majority of research on the effectiveness of Business Logo signs has employed search tasks, in which the participant was given a particular business to search for and asked to determine if the business was present on the sign. This has shown to be a useful tool in determining driver ability to identify a target of interest; therefore, the present research employed a similar technique. In past studies, however, signs were typically presented for pre-determined exposure times, followed by a participant response of either “yes” or “no,” indicating whether a particular business was present. With a forced response like this, it is likely that some responses (whether correct or incorrect) were actually guesses by participants. Furthermore, it would be hard to distinguish between actual correct responses and correct guesses. Additionally, this method does not provide information on precisely how long it takes to correctly identify options available on the sign. Therefore, the present research utilized a search task in which the dependent measure was reaction time. That is, the amount of time it takes to determine whether or not a particular business is present on the sign.

It can be assumed that there are typically two principal ways of using Business Logo signs. One way occurs when drivers have a particular requirement to be fulfilled (e.g., they are running out

of gas) and have a particular business in mind that they are searching for (e.g., they have an Exxon gas card and are looking for an exit that has an Exxon gas station). The other way occurs when drivers have a need for a particular service (e.g., they are hungry and need somewhere to eat) and want to know the options that are available in order to determine if they want to take the next exit. In the latter situation, if the driver locates a business of interest within the first couple options he/she sees, it may not matter to the driver whether he/she saw the remaining targets as he/she may have already decided to take the exit. On the contrary, if the driver is unable to make a decision as he/she is viewing the options, then he/she may rely partially on recognition and memory to continue the decision making process.

Whether drivers are searching Business Logo signs for a particular business or looking at all available options, the purpose of adding logo panels is to provide more information to drivers about the available services. Therefore, in an attempt to capture the effectiveness of the signs under both uses, the present research was broken up into two different tasks: search task and recognition task.

RESEARCH GOALS

The goal of this research was to determine the effectiveness of Business Logo signs when four, six, or nine logo panels are presented on a sign. In other words, to what extent can drivers identify available options indicated by the sign when they are presented with four, six, or nine businesses?

Objectives

The current research study was designed with the following three objectives in mind:

1. Evaluate effectiveness of Business Logo signs with varying numbers of logo panels based on driver ability to correctly identify business information indicated by the signs.
2. Evaluate effectiveness of Business Logo signs where the logo panel is a designed artistic logo versus standard highway text (using the FHWA Standard Alphabet).
3. Produce a summary report which provides results and recommendations, as necessary, about the number of logo panels used on Business Logo signs.

STIMULUS DEVELOPMENT

A sample was taken of approximately 80 Business Logo signs within an approximate 100 mile stretch of Interstate 95 in Virginia. The sample included five service types: Gas (n = 68 panels), Food (n = 131 panels), Lodging (n = 87 panels), Attractions (n = 32 panels) and Camping (n = 4 panels). The Business Logo signs were evaluated for the type of establishment (national/regional chain or local business) as well as how the information for the establishment was presented on the sign (logo or text). The “logo” presentation type was considered anything with specific text, coloring, or insignias and “text” presentation type was considered anything with plain black and white text, or very simple text with minimal detail.

Within the sample, it was found that the majority of Gas, Food and Lodging panels were primarily logo-based national or regional establishments, while Attractions and Camping panels tended to be text-based local establishments. The specific results are shown in Table 1. All text-based panels, regardless of service type, were local services (i.e., text-only panels were only seen for local businesses, not for regional or national businesses).

Table 1. Results of Business Logo Sign Sample (Highest Percentages in Each Service Type are Shown in Red)

Type of Presentation	Service Type				
	Gas	***Food***	***Lodging***	***Attractions***	***Camping***
Text	1%	5%	11%	**69%**	**50%**
Logo	**99%**	**95%**	**89%**	31%	50%
Type of Business					
Local	18%	18%	20%	**97%**	**75%**
National/Regional	**82%**	**82%**	**80%**	3%	25%

Interstate Logos, L.L.C., which administers and operates logo signing programs for DOTs in 21 states, provided information on the top national and regional logos by service category in Virginia, as well as some text-based and local samples.

The research team identified 15 food services and 15 gas services that were used as businesses on the test signs; however, each sign stayed service type specific (i.e., a sign had either all gas services or all food services). Each service type included 12 national or regional businesses and 3 local businesses in attempt to mirror the ratio of national to local businesses observed in Table 1. The stimuli were developed based on the Panel Type and Target Type variables.

Panel Type

The research team evaluated Business Logo signs at three levels: four logo panels, six logo panels, and nine logo panels. The layouts of each sign type are shown in Figure 1.

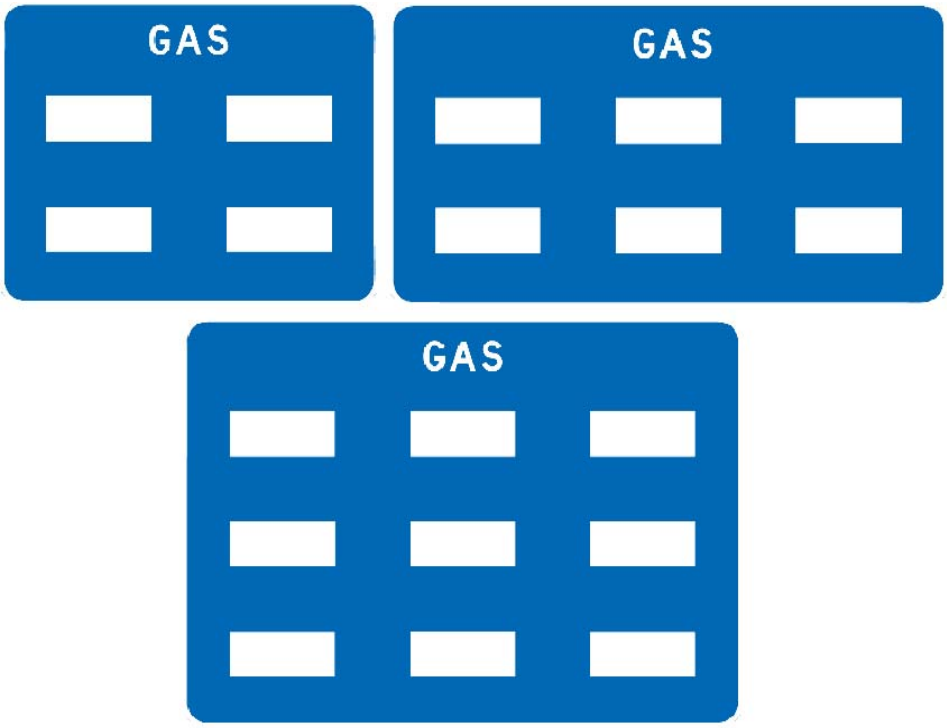

Figure 1. Layout for Four Panel, Six Panel, and Nine Panel Business Logo Signs.

Target Type

The research team presented signs in Logo Target Type or Text Target Type and each sign stayed Target Type specific (i.e., a sign had either all Logo panels or all Text panels). Logo Target Type refers to the font, coloring, symbol, insignia, or any combination of the aforementioned qualities which make up an emblem, or logo, for a business. Text Target Type simply provided the names of the same establishments used for the Logo Target Types; however, they were presented in highway text with no unique coloring or symbols. An example of each is shown in Figure 2.

Figure 2. Example of Logo Target and Text Target Types.

The Logo Target Type was used to represent what drivers are likely to see most often, especially on food, gas and lodging Business Logo signs where logo panels are primarily national or regional chains. The Text Target Type was used to represent what drivers are more likely to see in other service categories (e.g., attractions) which may rely primarily on text as they tend to be local or independent establishments.

METHOD

RESEARCH DESIGN

The research was conducted at the Turner Fairbank Highway Research Center in the Highway Sign Laboratory (Sign Lab). In the Sign Lab, software was used in conjunction with a 60" LCD display. The software used for testing electronically collected the required data and saved output data files for analysis.

All signs were displayed to participants at a simulated distance of 121 ft. This distance was selected to ensure that the sign would be legible to all participants. The MUTCD requires a minimum letter and numeral height of 8 in. for the panels of Business Logo signs. Based on 8 in. letter height, and assuming 20/40 visual acuity (which is the minimum acuity required to receive an unrestricted license in most states) and a travel speed of 55 mph, there would be approximately 232 ft, or 2.88 s, between the point where the sign becomes legible and the point where the driver passes the sign. Therefore, 121 ft also represented an approximate midway point of the total viewing distance.

Search Task

Participants performed a search task in which they were asked to report whether a particular business appeared on a Business Logo sign or not. They were seated in front of the display, with a keyboard on a desk in front of them. The keyboard contained two labeled keys, one marked "Yes" and the other marked "No." The dependent variable for this task was reaction time (RT). As a result, participants were instructed to respond, by pressing the corresponding key, as soon as they could determine whether or not the business was present on the sign. They were further instructed to keep their hands in the "ready position" at all times so that each hand was resting on top of the respective response key.

Prior to the experimental trials, participants were given two groups of practice trials. In the first group, trials were used to familiarize the participant with which hand corresponded with each response key (Yes/Target Present or No/Target Not Present), and also served as practice in responding quickly. The second group of practice trials mimicked the experimental trials exactly. These trials were used to provide more realistic practice, and to ensure participants understood the procedure and were pressing their responses as soon as they could determine presence or absence of their target business.

For the experimental trials, participants were shown a screen which indicated the name of a business, or the "target", they were looking for. They were instructed to state the name of the target aloud when they were ready to view the sign. Upon doing so, the target name disappeared and a small red "+" appeared in the center of the screen. This cross served as a fixation point for the participant prior to viewing the sign. After one second, the fixation point was replaced by a Business Logo sign that had four, six, or nine panels. Participants were to press the "Yes" key if the target business was present, or the "No" key if the target was not present.

Each participant viewed 72 signs of each Panel Type (four, six, and nine) and Target Type (Logo and Text) was shown equally within each Panel Type, as indicated by Table 1. Half of the search

trials presented targets that *did not* appear on the sign. Therefore, signs were also balanced by target presence (absent and present) and by service type (gas and food). Thus, each participant viewed a total of 216 stimuli. The order of sign presentation was randomized. The stimuli were presented in four groups of 54, so the participant was given a break after every 54 signs.

Table 2. Number of Search Task Trials for Each Combination of Target Type and Panel Type.

Target Type	Panel Type			Total
	4 Panel	*6 Panel*	*9 Panel*	
Text	36	36	36	108
Logo	36	36	36	108
Total	72	72	72	**N = 216**

Each of the 30 possible businesses (15 food and 15 gas) were rotated randomly as a target of the search task in order to prevent participants from learning to search for a particular target. The location of the target was balanced so that the target appeared in every possible position for each Panel Type, and was presented evenly between the columns on the signs. The businesses appearing on the remaining panels of the sign were also randomized.

Recognition Task

The search task was followed by a recognition task in which participants were shown a Business Logo sign for 2 seconds and asked to report the businesses, or targets, that they saw on the sign. Participants were given a separate response sheet that corresponded to each sign. The response sheet included the targets that were shown on the sign, as well as six distracter targets of the same category (gas or food) that were not shown on the sign. Thus, the response sheets for 4 panel signs contained 10 targets; for 6 panel signs contained 12 targets; and for 9 panel signs contained 15 targets. The targets were shown on the response sheet in the same target type (text or logo) as they were on the sign.

Participants stated when they were ready to view each sign. A fixation point appeared in the center of the screen for 1 s, and was then replaced by a four, six or nine panel sign, which remained on the screen for 2 s. After 2 s, the sign disappeared and the participant used his/her response sheet to mark the targets he/she recognized from the sign. He/she was asked to only circle targets which he/she recognized with high levels of confidence; he/she was instructed not to guess.

Participants viewed four signs for each Panel Type (four, six and nine) and Target Type (logo and text) was shown equally within each Panel Type, as indicated by Table 2. Thus, each participant viewed a total of 12 stimuli.

Table 3. Number of Report Task Trials for Each Combination of Target Type and Panel Type.

Target Type	Panel Type			Total
	4 Panel	*6 Panel*	*9 Panel*	
Text	2	2	2	6
Logo	2	2	2	6
Total	4	4	4	**N = 12**

PARTICIPANTS

Participants were recruited from the Washington, DC metropolitan area through the Human Factors Team research participant database. Participants were at least 18 years of age, possessed a valid U.S. driver's license, and passed a visual acuity test with a minimum of 20/40 vision, corrected if necessary.

One hundred and four participants completed the study. Prior to the start of the experiment, participants read and signed the Informed Consent form. Each participant was paid $30.00.

Of the 104 participants that completed the study, 95 participants produced usable data for analysis of the search task. Of those included in the analysis, 45 participants were male and 50 were female. Participants were divided into two age groups, younger (18-49 years, M = 34 years) and older (50+ years, M = 63 years).

Of the 104 participants that completed the study, 93 participants produced usable data for analysis of the recognition task. Of those included in the analysis, 46 participants were male and 47 were female. The average age was 47 years old.

RESULTS

SEARCH TASK RESULTS

Preliminary data analysis was performed to determine which participants (if any) should be excluded from the final data analysis. The Inter-Quartile Range (IQR) of correct response RTs was calculated for each participant. The IQR is a measure of dispersion; the range of the middle 50% of the data. Those individuals with an IQR greater than 2,000 ms were identified and eliminated. Further review of such individuals' RT plots showed atypical response distributions; thus, confirming their removal (i.e., participants with an IQR greater than 2,000 ms also had response distributions which were not representative of typical reaction time data, indicating they were likely not performing the task as instructed).

For the final data analysis, only correct response RTs were included. The percentages of correct responses shown in Table 4 have been rounded to the nearest integer.

Table 4. Percentage of Correct Responses in Search Task

Target Type	Target Presence	Panel Type		
		4 Panel	*6 Panel*	*9 Panel*
Text	***Present***	97%	97%	93%
	Absent	99%	99%	99%
Logo	***Present***	88%	92%	86%
	Absent	99%	99%	88%

From these correct response RTs, a 10% trimmed mean was calculated for each combination of Panel Type and Target Type for each individual. All combinations of the independent variables (Age Group, Panel Type, and Target Type) were included in a Generalized Estimating Equations (GEE) model for analysis. A GEE model was used for analysis, as it can handle correlated responses which are non-normal. Follow up analyses were produced for all significant effects.

Wald Type 3 analyses were calculated to determine which factors (if any) had a significant effect on mean RT. As shown in Table 5, all three first-order and second-order effects were significant at the 0.05 significance level. Because these second-order interaction effects were significant, no main effects will be discussed hereafter.

Table 5. Results from GEE Model for Mean Reaction Time Based on Age Group, Panel Type, and Target Type. (*Indicates a Significant Result)

Variable	DF	Chi-Square	Pr > ChiSq
Age Group	1	53.41	<0.01*
Panel Type	2	2251.95	<0.01*
Target Type	1	29.92	<0.01*
Age Group x Panel Type	2	30.61	<0.01*
Age Group x Target Type	1	21.69	<0.01*
Panel Type x Target Type	2	19.97	<0.01*
Age Group x Panel Type x Target Type	2	0.98	0.61

Interaction of Age Group and Panel Type

As shown in Table 6, reaction time increased both with age and the number of panels. Among the younger participants, the following were true: (1) Mean RT for 4 panel signs was significantly shorter than mean RT for 6 panel signs ($Z = -23.70$, $p < 0.01$); and (2) Mean RT for 6 panel signs was significantly shorter than mean RT for 9 panel signs ($Z = -28.16$, $p < 0.01$). Among older participants, the following were true: (1) Mean RT for 4 panel signs was significantly shorter than mean RT for 6 panel signs ($Z = -26.07$, $p < 0.01$); and (2) Mean RT for 6 panel signs was significantly shorter than mean RT for 9 panel signs ($Z = -29.54$, $p < 0.01$). There was no significant difference between mean RT for 4 panel signs among older participants and mean RT for 6 panel signs among younger participants. Additionally, there was no significant difference between mean RT for 6 panel signs among older participants and mean RT for 9 panel signs among younger participants.

Table 6. Mean Reaction Time (ms) by Age Group and Panel Type.

Age Group	Panel Type	Mean RT (ms)
Younger	4 Panel	1298.63
	6 Panel	1639.00
	9 Panel	2219.66
Older	4 Panel	1720.54
	6 Panel	2175.59
	9 Panel	2868.70

Figure 3 visually depicts the significant interaction between Age Group and Panel Type. The mean RT difference between younger and older participants for 4 panel signs, 6 panel signs, and 9 panel signs was approximately 422 ms, 537 ms, and 649 ms, respectively. Therefore each addition of panels yielded about a 110 ms increase in the difference in mean RT between younger and older participants. If this interaction was not significant, then the mean RT difference between age groups would be constant.

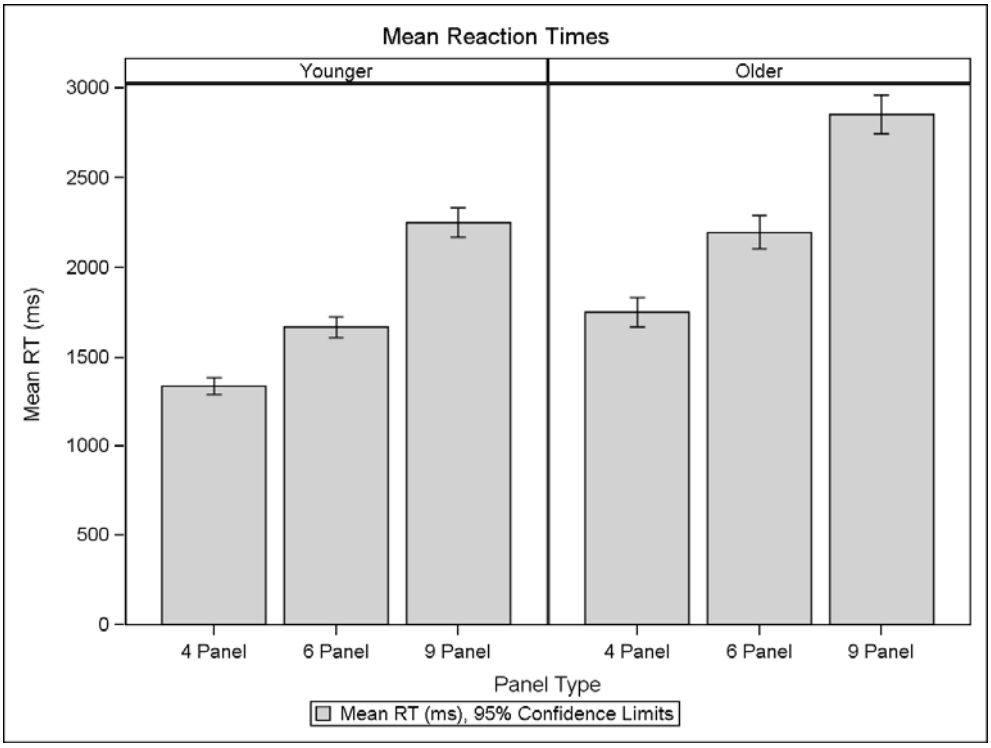

Figure 3. Mean RT (ms) by Age Group and Panel Type.

Interaction of Age Group and Target Type

As shown in Figure 4, RT increased with age for both target types. When considering only younger participants, there was no difference in mean RT for logo targets and text targets. When considering only older participants, this was not the case. Among these participants, the mean RT for text targets was significantly shorter than the mean RT for logo targets, ($Z = 7.31$, $p < 0.01$). The reaction times for age group and target types are shown in Table 7.

Table 7. Mean Reaction Time (ms) by Age Group and Target Type.

Age Group	Target Type	Mean RT (ms)
Younger	Text	1712.10
	Logo	1726.10
Older	Text	2167.72
	Logo	2342.17

The interaction between age group and target type is visually depicted in Figure 4.

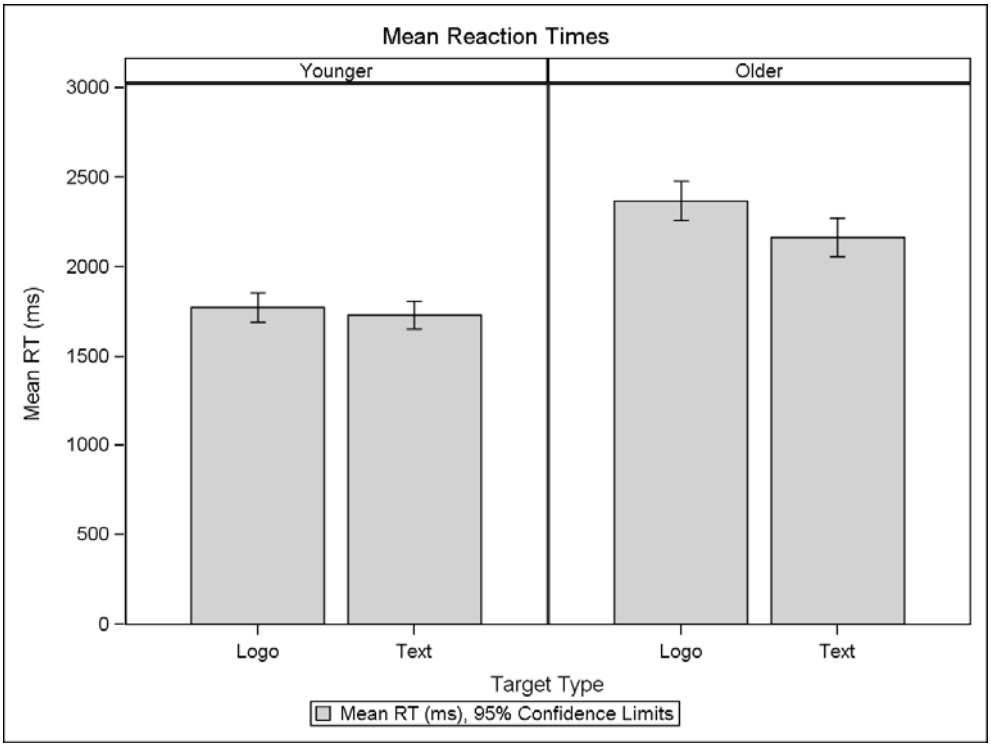

Figure 4. Mean RT (ms) by Age Group and Target Type.

Interaction of Panel Type and Target Type

Reaction time increased with the number of panels for both target types. When considering only 4 panel signs, the mean RT for text targets was significantly shorter than the mean RT for logo targets, ($Z = 9.15$, $p < 0.01$). Similarly, the mean RT for text targets was significantly shorter than the mean RT for logo targets on 6 panel signs ($Z = 4.92$, $p < 0.01$). However, for 9 panel signs there was no difference in mean RT for text targets and logo targets. The mean RTs for target type and panel type are shown in Table 8.

Table 8. Mean Reaction Time (ms) by Target Type and Panel Type.

Target Type	Panel Type	Mean RT (ms)
Text	4 Panel	1421.54
	6 Panel	1835.39
	9 Panel	2498.05
Logo	4 Panel	1557.66
	6 Panel	1928.37
	9 Panel	2528.82

Figure 5 visually depicts the interaction between these two variables.

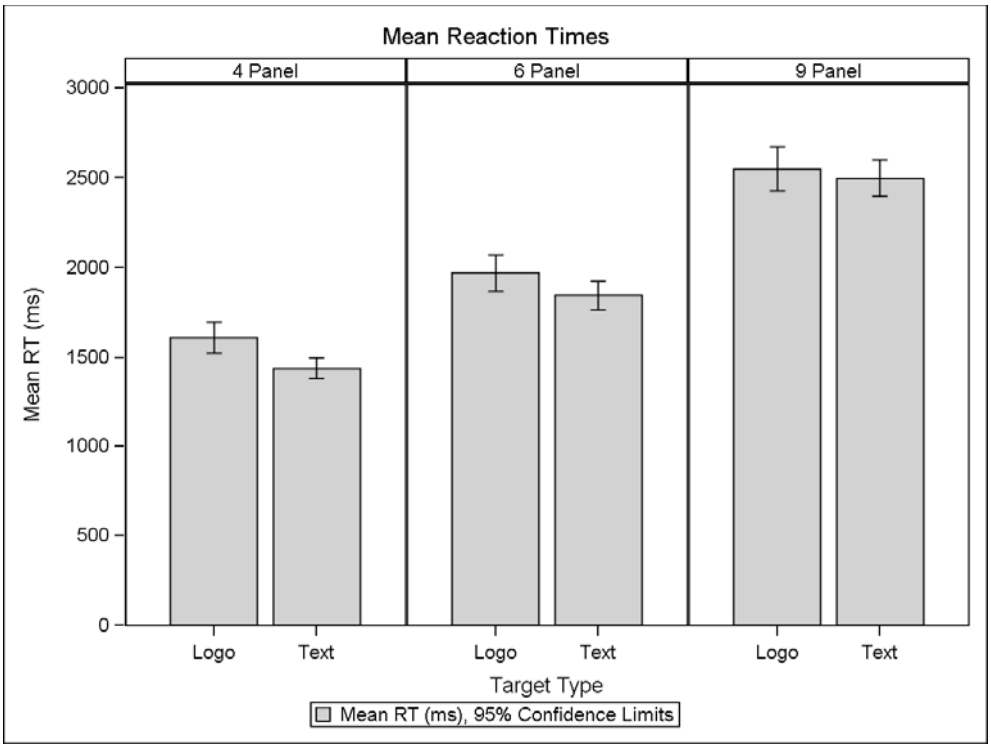

Figure 5. Mean RT (ms) by Panel Type and Target Type.

RECOGNITION TASK RESULTS

Because there were a different number of possible responses for each panel type, it was unreasonable to compare the number of correct responses between panel types. Therefore, responses for each panel type were analyzed separately.

A GEE model with multinomial response distribution and cumulative logit link function was used to analyze Target Type. For 4 panel signs, Wald Type 3 analyses indicated that target type did not have a significant effect on the number of correct responses. The observed response distributions are shown in Table 9. The mean number of correct responses was 3.23 and 3.13 for logo and text signs, respectively.

Table 9. Observed Distributions for the Number of Correct Responses for 4 Panel Signs (Columns do Not Sum to 100% Due to Rounding).

Correct Responses	Logo (%)	Text (%)
0	0.00	1.61
1	4.84	4.30
2	17.20	18.28
3	28.49	31.18
4	49.46	44.62

For 6 panel signs, Wald Type 3 analyses indicated that target type did not have a significant effect on the number of correct responses. The observed response distributions are shown in

Table 10. The mean number of correct responses was 3.44 and 3.48 for logo and text signs, respectively.

Table 10. Observed Distributions for the Number of Correct Responses for 6 Panel Signs (Columns May Not Sum to 100% Due to Rounding).

Correct Responses	Logo (%)	Text (%)
0	0.00	0.00
1	1.08	3.23
2	13.44	10.75
3	39.78	32.80
4	32.80	42.47
5	12.37	9.14
6	0.54	1.61

For 9 panel signs, Wald Type 3 analyses indicated that target type did have a significant effect on the number of correct responses ($\chi^2 = 20.69$, $p < 0.01$). Participants were able to recognize more logo targets correctly (M = 3.77) than text targets (M = 3.39; see Figure 6).

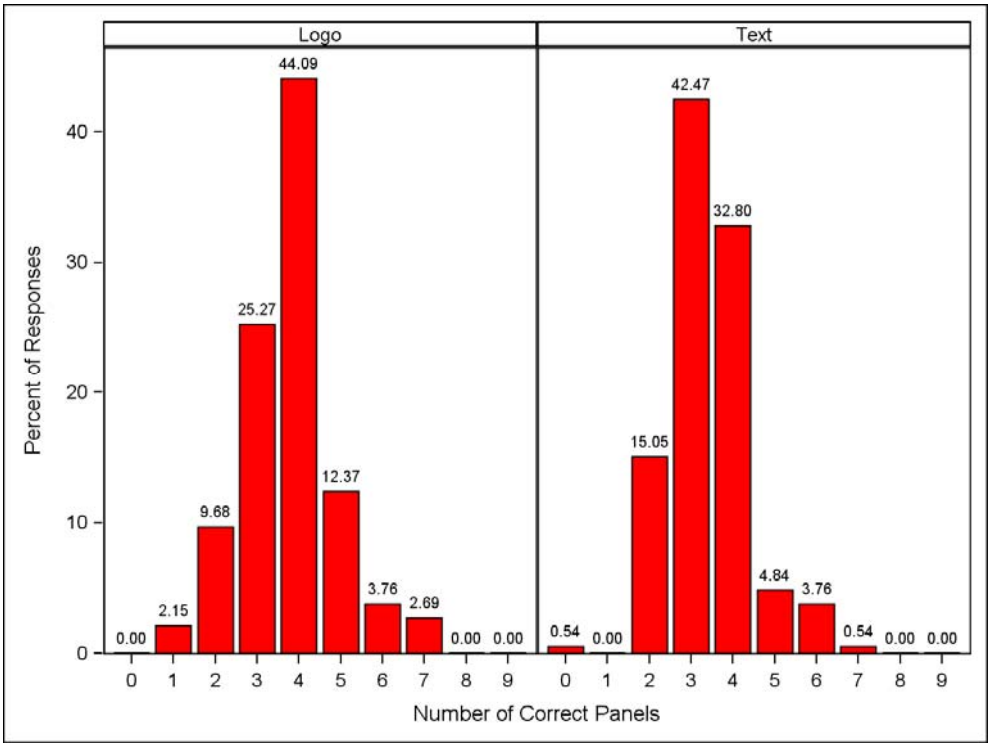

Figure 6. Observed Distributions for the Number of Correct Responses for 9 Panel Signs (Columns May Not Sum to 100% Due to Rounding).

False Alarm Rate

Participants were asked only to circle targets which they recognized with high levels of confidence; they were instructed not to guess. False alarms (instances when the participant

circled a target that was not present) were recorded. The rate of false alarms per target was calculated for each panel type by target type.

For 4 panel signs, participants were allowed to correctly circle a maximum of 744 targets (2 signs x 4 targets x 93 participants) for each target type. Of this maximum, there were 67 false alarms, or a rate of approximately 9%, for logo targets and there were 72 false alarms, or a rate of approximately 10%, for text targets.

For 6 panel signs, participants were allowed to correctly circle a maximum of 1,116 targets (2 signs x 6 targets x 93 participants) for each target type. Of this maximum, there were 118 false alarms, or a rate of approximately 11%, for logo targets and there were 90 false alarms, or a rate of approximately 8%, for text targets.

For 9 panel signs, participants were allowed to correctly circle a maximum of 1,674 targets (2 signs x 9 targets x 93 participants) for each target type. Of this maximum, there were 121 false alarms, or a rate of approximately 7%, for logo targets and there were 147 false alarms, or a rate of approximately 9%, for text targets.

Percent of Time Correct by Position

The percent of correct target recognition was calculated by target position for each panel type. It was hoped that results would lend understanding to how participants visually navigated the sign during the 2s that it displayed. Figure 7 through Figure 9 depict the percent of time correct by target position for 4 panel, 6 panel, and 9 panel signs, respectively.

For all three panel types, the highest recognition occurred for positions A, B and C. When averaging the percent of time correct for all positions on a sign, there is a decrease in correct recognition as the number of panels increases, with mean correct percentages of 80.73% for 4 panel signs, 63.81% for 6 panel signs and 50.84% for 9 panel signs. Additionally, the range between the position with the highest recognition and the position with the lowest recognition expands, with 14.57% for 4 panel signs, 18.82% for 6 panel signs and 37.81% for 9 panel signs.

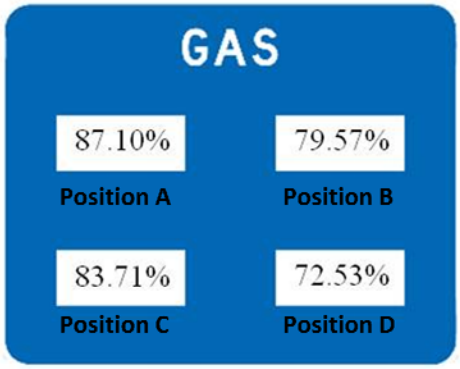

Figure 7. Percent of time correct by target position for 4 panel signs.

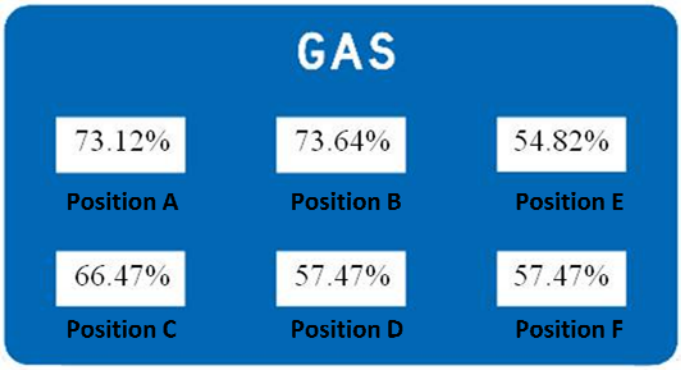

Figure 8. Percent of time correct by target position for 6 panel signs.

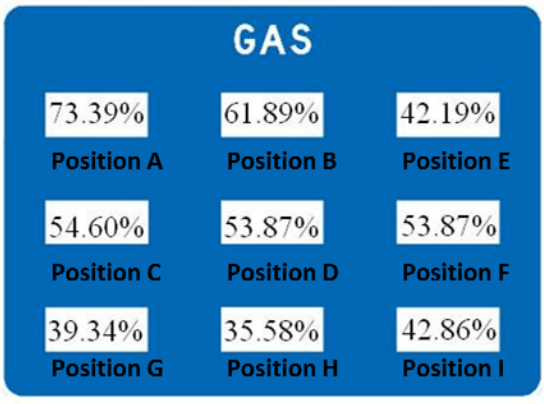

Figure 9. Percent of time correct by target position for 9 panel signs.

CONCLUSIONS

Reaction time increases for all drivers as the number of panels per sign increases. Additionally, the difference between younger drivers and older drivers expands as the number of panels increases. This indicates that increasing the number of panels per sign has the potential to have a more significant impact on older drivers than on younger drivers. Additionally, older drivers are affected by the type of target (text vs. logo), whereas younger drivers are not. In the search task, older drivers took significantly longer to identify the presence of a target among all logos than they did among text alone. It is possible that older drivers may be less familiar with logos in general than are younger drivers.

When collapsing across age groups, all drivers took significantly longer to identify targets among logos than among text when viewing 4 panel signs and 6 panel signs. There was no significant difference in reaction time by target type when viewing 9 panel signs. This may indicate that any possible advantage that text provides over logos when searching for a target, is no longer helpful at the 9 panel level.

The recognition task indicates that when drivers have a limited time to view each sign (in this case 2 s), they tend to report between 3 and 4 businesses on average, regardless of how many panels are on the sign. Target type has an effect on target recognition for 9 panel signs only; however, the difference is small, with an average of 3.77 recognized logo targets and 3.39 recognized text targets.

The percentages of correct target recognition by position on the sign show that, for all three panel types, the highest recognition occurred for the targets in positions A, B and C. With each increase in the number of panels per sign, there is a general decrease in the percentage of correct target recognition for all positions on the sign. Such a result is to be expected as there are more possible items available to which to attend. However, target recognition only drops below 50% on 9 panel signs. In this bottom row (positions G, H and I) recognition rates are 39.34%, 35.58% and 42.86%, respectively, and position E drops to 42.19% as well; all other target positions in all sign types have recognition rates above 50%.

Mean RT for nine panel signs was approximately 2.2 s for younger drivers and approximately 2.9 s for older drivers. When considering drivers of all ages, increasing the number of panels from six to nine brings mean reaction times from approximately 1.8 seconds to approximately 2.5 seconds for text signs and from approximately 1.9 seconds to approximately 2.5 seconds for logo signs. As previous literature states, eye glances away from the forward roadway for greater than 2 s are unsafe and increase driver risk of safety critical events to over two times the risk of normal, baseline driving.[2,3] Furthermore, the recognition rate of the additional row for 9 panel signs is only about 39%, on average. Therefore, the benefit of providing more service information to the driver is presumably not great enough to outweigh the potential risk of information overload and driver distraction.

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