St. Louis Inlaid Pavement Marker Survey

Prepared by
Applied Research Associates, Inc.

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16. Abstract
This report presents results from a survey of a diverse group of motorists perceptions and opinions of inlaid pavement markers. Respondents participated in one of three ways: They (a) experienced the markers first-hand by driving a designated route with researchers and then completed a questionnaire, (b) were approached at a highway rest stop outside of St. Louis and asked to complete a questionnaire, or (c) were solicited via e-mail and asked to complete an online questionnaire. Results indicate that motorists overwhelmingly reported favorable perceptions and opinions of inlaid pavement markers. They reported that the markers enhance visibility of lane delineations, particularly while driving in rain and fog, thus making them feel safer while driving. Roughly two thirds of all respondents reported that it would be "extremely useful" to have inlaid pavement markers on all roadways, with another 15% of respondents reporting that such omnipresence would be "very useful." No differences in responding were observed between age, gender, or occupation groups.

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Prepared for the Missouri Department of Transportation

January 4, 2017

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Technical Summary

The Missouri Department of Transportation (MoDOT) is evaluating the performance of plastic (non-metal), recessed pavement markers in sections of three interstate routes in the St. Louis area (I-70, I-44, and I-270). This report presents data on motorists' perceptions and opinions of those installed pavement markers.

The purpose of this project was to evaluate drivers' perceptions of inlaid pavement marker performance. To do this, researchers administered surveys to a regional, stratified, random sample of Missouri resident drivers, non-resident drivers who regularly utilize Missouri highways, and to St. Louis-area law enforcement personnel. These respondents provided survey data in one of three ways:

1. Guided observation: Respondents experienced the inlaid pavement markers first-hand as passengers in a vehicle driven by researchers through relevant segments of highway. Respondents then viewed a photograph of the inlaid pavement marker and provided perceptions and opinions of the markers on a pen-and-paper survey.
2. Public solicitation: Respondents encountered researchers at a rest stop near the I-70 site, where they viewed the photo of the inlaid pavement marker and provided their perceptions and opinions of the markers on a pen-and-paper survey.
3. Online survey: Respondents received an e-mail with a link to an online survey, a digital photo of the inlaid pavement marker, and a description of where the pavement markers were embedded, and then provided their perceptions and opinions of the markers via the online survey.

Participants overwhelmingly indicated that they recognized the reflectors from previous driving experiences (87%), the reflectors help when driving at night in the rain (89%) and at night in the fog (81%), the reflectors improve visibility by an average of 77%, and it would be very useful to have the reflectors on all roads (mean rating = 6.42; sixty-four percent of respondents recorded a rating of 7, corresponding to "Extremely useful"). There was no difference in these responses as a function of gender (male vs. female), age (< 40 years vs. 40-60 years vs. > 60 years), or occupation (transportation vs. non-transportation). Only the number of highway hours typically driven by a respondent influenced his/her perception/opinion of the inlaid pavement markers: As drivers spend more time driving on highways, they tend to perceive greater gains in visibility from inlaid pavement markers.

This study surveyed a diverse sample of motorists who use Missouri State highways. These motorists overwhelmingly reported favorable perceptions and opinions of inlaid pavement markers. They tended to report that the markers enhance visibility of lane delineations, particularly while driving in rain and fog, thus making them feel safer while driving. Roughly two thirds of all respondents reported that it would be "extremely useful" to have inlaid pavement markers on all roadways, with another 15% of respondents reporting that such omnipresence would be "very useful."

Chapter 1. Introduction

One goal of the Missouri Department of Transportation (MoDOT) is to maximize driver safety through enhancements in infrastructure. In support of this goal, MoDOT seeks to enhance driver safety through improving lane delineation (or lane visibility) on Missouri's roadways. One possible way to improve lane delineation is to embed reflective pavement markers in the roadway. However, contact with vehicles (e.g., snowplows) can dislodge embedded reflectors and render them hazardous to motorists. Dislodged reflectors are particularly problematic when their housings are made of cast iron. Hence, MoDOT has installed, and is testing the performance of, non-metal, recessed pavement markers in sections of three interstate routes in the St. Louis area (I-70, I-44, and I-270). MoDOT also desired motorists' perceptions and opinions of those installed pavement markers and awarded a research project to Applied Research Associates (ARA) to conduct a comprehensive user survey. This report presents the results the survey.

The purpose of this project was to evaluate drivers' perceptions of inlaid pavement marker performance. To do this, ARA administered surveys to a regional, stratified, random sample of Missouri resident drivers, non-resident drivers who regularly utilize Missouri highways, and to St. Louis-area law enforcement personnel. These respondents provided survey data in one of three ways:

1. Guided observation: Respondents experienced the inlaid pavement markers first-hand as passengers in a vehicle driven by researchers through relevant segments of highway. Respondents then viewed a photograph of the inlaid pavement marker (see Appendix A) and provided perceptions and opinions of the markers on a pen-and-paper survey (see Appendix B).
2. Public solicitation: Respondents encountered researchers at a rest stop near the I-70 site, where they viewed the photo of the inlaid pavement marker and provided their perceptions and opinions of the markers on a pen-and-paper survey (see Appendix C).
3. Online survey: Respondents received an e-mail with a link to an online survey, a digital photo of the inlaid pavement marker, and a description of where the pavement markers were embedded, and then provided their perceptions and opinions of the markers via the online survey (see Appendix D).

All respondents answered questions relevant to the inlaid pavement markers' utility for enhancing lane visibility and roadway safety, and reported demographic information (see Appendix E).

Results Overview

As a general overview of the results, the five critical questions posed to respondents were:

- Do you recognize the inlaid pavement markers from previous driving experience? (Yes/No)
- Do you think these reflectors help driving at night when it is raining? (Yes/No)
- Do you think these reflectors help driving at night when it is foggy? (Yes/No)

- How much do these reflectors improve visibility compared to no reflectors? (0-100%)
- How useful would it be to have these reflectors on all roadways? (1-7; 1 = Not at all useful, 7 = Extremely useful)

Figure 1 summarizes all participant responses to these questions. Participants overwhelmingly indicated that they recognized the reflectors from previous driving experiences (87%), the reflectors help when driving at night in the rain (89%) and at night in the fog (81%), the reflectors improve visibility by an average of 77%, and it would be very useful to have the reflectors on all roads (mean rating = 6.42; sixty-four percent of respondents recorded a rating of 7, corresponding to "Extremely useful"). There was no difference in these responses as a function of gender (male vs. female), age (< 40 years vs. 40-60 years vs. > 60 years), or occupation (transportation vs. non-transportation). The only influence of a demographic variable on a perception/opinion variable was a correlation between the number of hours respondents typically drive on the highway per week and their estimate of how much inlaid pavement markers improve visibility, $r = .47$, $p = .002$. As the number of highway hours increased, respondents' estimates of improvement also increased, suggesting that as drivers spend more time driving on highways, they tend to perceive greater gains in visibility from inlaid pavement markers.

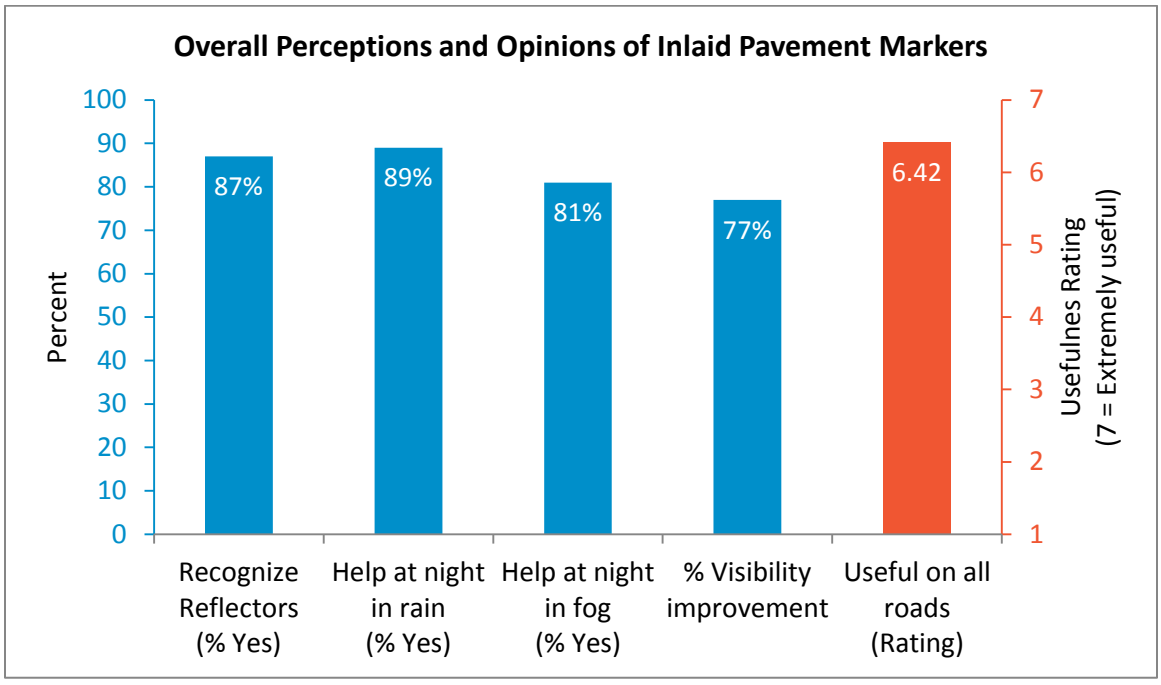

Figure 1. **Overall Perceptions and Opinions of Inlaid Pavement Markers.**
Note: For the first three bars, indicating the percentage of participants responding "yes," n = 53. For the next two bars, indicating the percentage of visibility improvement and the potential usefulness of the markers on all roads, n = 50.

The remaining sections present detailed descriptions of the procedure and results from each data collection activity.

Chapter 2. Guided Observation

Participants

Twenty Missouri drivers with experience driving on highways participated in the guided observation portion of the study. We recruited these participants through an online solicitation on craigslist.org (see Appendix F). We stratified observation participants into two groups: age 40 years or younger and age 60 years or older. We deselected motorists between age 40 and 60 years to avoid recruiting participants with potentially undiagnosed and uncorrected visual impairments.[1] Research indicates that common age-related vision problems begin around age 40, increase in frequency after age 50, and become even more prominent after age 60, when several age-related vision issues, such as cataracts, reduced peripheral vision, and trouble with low lighting become very common (e.g., see Chapanis, 1950; National Eye Institute of the National Institutes of Health). Table 1 presents demographic data for the guided observation participants.

Table 1. ***Observer Participant Demographics***

	Age 18-40 (n = 10)	Age 60-75 (n = 9)
Mean age at licensure	16.50 (SD = 0.76)	16.11 (SD = 0.33)
Gender	Female = 40% (n = 4) Male = 60% (n = 6)	Female = 67% (n = 6) Male = 33% (n = 3)
Education	Some college = 40% (n = 4) Baccalaureate = 20% (n = 2) Advanced degree = 20% (n = 2) No Response = 20% (n = 2)	Some College = 33% (n = 3) Baccalaureate = 44% (n = 4) Advanced degree = 22% (n = 2)
Worked in transportation	No = 80% (n = 8) Yes = 0% (n = 0) No response = 20% (n = 2)	No = 78% (n = 7) Yes = 22% (n = 2)
Highway drive hours per week	8.06 (SD = 4.87)	13.17 (SD = 14.53)
Years as MO resident	20.25 (SD = 10.39)	48.78 (SD = 13.32)
Accident resulting from road conditions	No = 90% (n = 9) Yes = 10% (n = 1)	No = 89% (n = 8) Yes = 11% (n = 1)

Note: Two observers reported having worked in transportation. One is a retired commercial bus driver and the other is a traffic systems specialist.

Materials

Questionnaire: Participants completed a pen-and-paper questionnaire containing items relevant to their perceptions and opinions of the roadway reflectors they observed on their ride with

[1] One of our observation participants was 45 years old; therefore, we excluded this participant from the data analysis, yielding a final sample of 19 participants.

researchers. They also completed a demographic questionnaire containing items pertaining to their age, gender, education, occupation, and general driving experience.

Photo: Participants viewed a color photo of the inlaid pavement marker to clarify the element of the roadway infrastructure they were reporting on. The photo, obtained from MoDOT, was on 8.5 x 11 inch paper.

Passenger van: Participants rode in a passenger van driven by a member of the research team. The van accommodated a maximum of eight people: 1 driver, 1 researcher, and up to six observers. Researchers arranged participants in the van to allow maximum visibility through the windshield for each participant. For example, taller observers who might obstruct the view of shorter observers were placed in the back of the van and were later rotated forward if they required a better view of the road ahead.

Procedure

All guided observation participants assembled at a specified location prior to their scheduled session. Sessions occurred after sunset to allow pavement marker visibility. When participants arrived, they showed their driver's license to a researcher and signed in. Researchers viewed driver's licenses to confirm each participant's age and licensure. After all session participants arrived, researchers informed them that they would be driven on the highway and they should pay attention to features on and around the roadway. Researchers told participants to attend only to what they could see through the windshield of the van, and not attend to elements on the side of the road or completely off the road, such as geographical landmarks or commercial structures. Researchers also told participants to take note of roadway features, but to remain silent until asked for their feedback. This was to prevent one participant from influencing what another participant was attending to. At this time, researchers did not indicate that participants should attend to inlaid pavement markers. After all session participants indicated understanding the directions, they entered the vehicle, occupied seats designated by the instructor, and fastened their safety belts. After all passengers were seated and safety belts were fastened, the van driver proceeded on a clockwise route starting at Exit 277b of I-44W, continuing onto I-270N, then I-64E, I-170N, I-70E, and completing the loop by returning to I-44W and exiting at Exit 277b (see Figure 2).

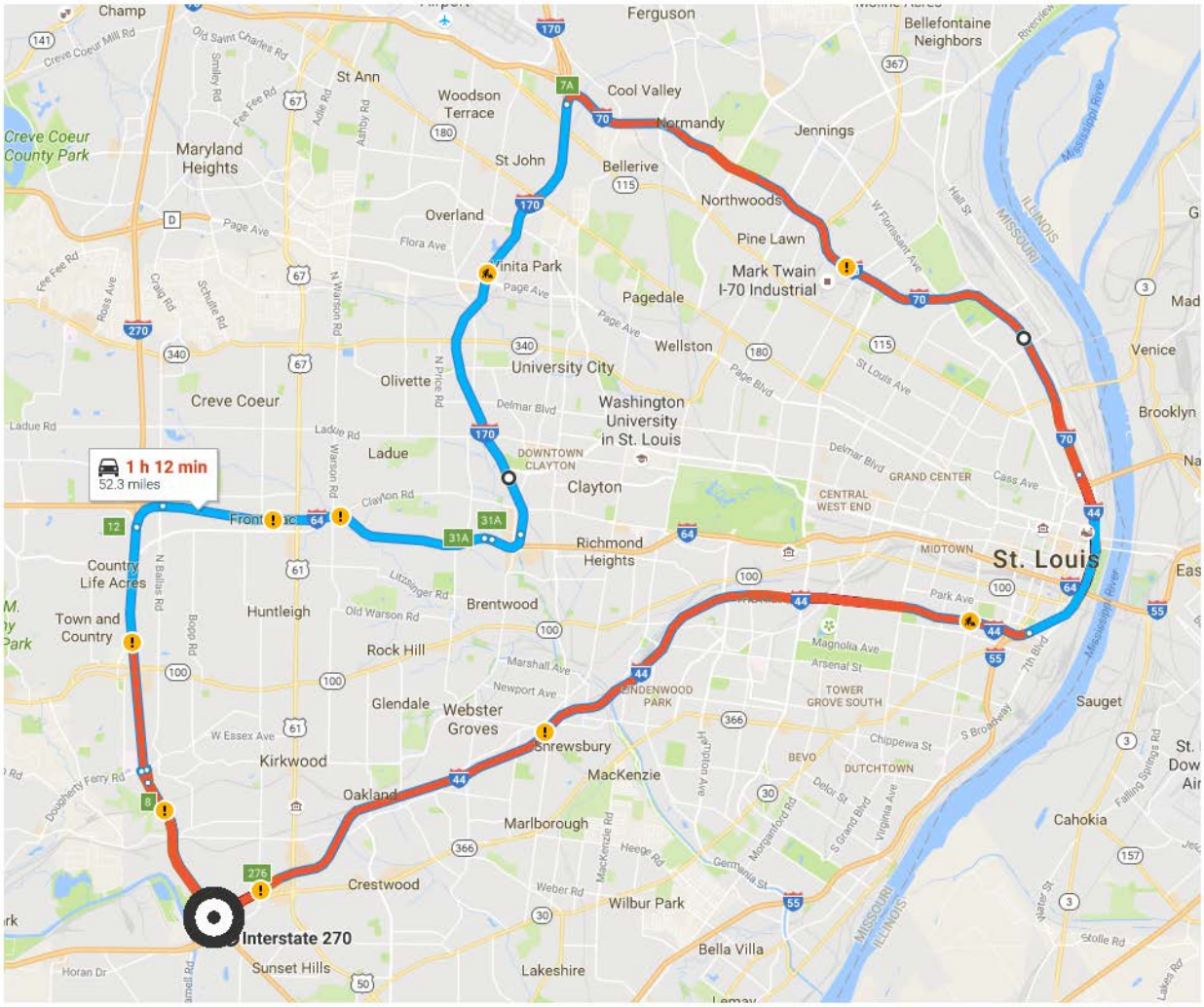

Figure 2. **Driving route around St. Louis.**
Note: The route began and ended near the black and white bullseye on the map. Red highlights indicate segments with inlaid pavement markers.

The route consisted of roughly 52 miles of highway and took approximately one hour to drive. After reaching I-170N, but before entering I-70E, the researcher in the van asked participants to indicate what they had noticed thus far on the ride. After recording participants' initial observations, the researcher asked participants if they had noticed the inlaid pavement markers on I-270N. The researcher then asked participants to focus only on the inlaid pavement markers for the remainder of the ride, and asked them to consider what the markers might mean for visibility and safety, and how the markers might perform in different traffic and weather conditions. As the group continued along the route, the researcher recorded participants' public comments. After completing the route, participants viewed a photo of an inlaid pavement marker and completed a questionnaire of their perceptions and opinions of the inlaid pavement markers. After completing this questionnaire, they provided some demographic information and

concluded the session. At the conclusion of the session, researchers debriefed participants regarding the purpose of the study, paid them $30 as compensation for their time, and thanked them for their participation. We conducted six sessions, each with 1-6 observers. Each session lasted approximately 90 minutes, including briefing, ride along, and questionnaire completion.

Results

Analysis of the contemporaneous notes recorded by the researcher during each session revealed that only two of 19 observers spontaneously noticed the inlaid pavement markers. The following results comprise observers' responses following the conclusion of the ride. They are organized by question. In addition to reporting general results, we report differences between age groups (< 40 years old vs. > 60 years old).

Did you notice these reflectors on the drive we just took?

All observers (100%) indicated having noticed the reflectors on the drive. In a follow-up question (what did you notice?), observers indicated the general frequency with which they noticed the reflectors, for example: [2]

- Placement was inconsistent, irregular, or poor. (11)
- "Some were missing."
- At times reflectors appeared as single reflectors, whereas at other times they appeared as double reflectors.

Observers also indicated the conditions under which the reflectors were more perceptible, for example, they were more visible:

- On black surfaces. (2)
- When they appeared as double (or two closely positioned) reflectors. (2)
- When the road had fewer overhead lights or was generally poorly lit.

[2] Parenthetical values following a bulleted item indicate how many respondents reported this response.

Do you recognize these reflectors from previous driving experiences?

Overall, 79% of respondents reported recognizing the reflectors from previous driving experiences. There was no statistically significant difference between age groups on this question (see Figure 3).

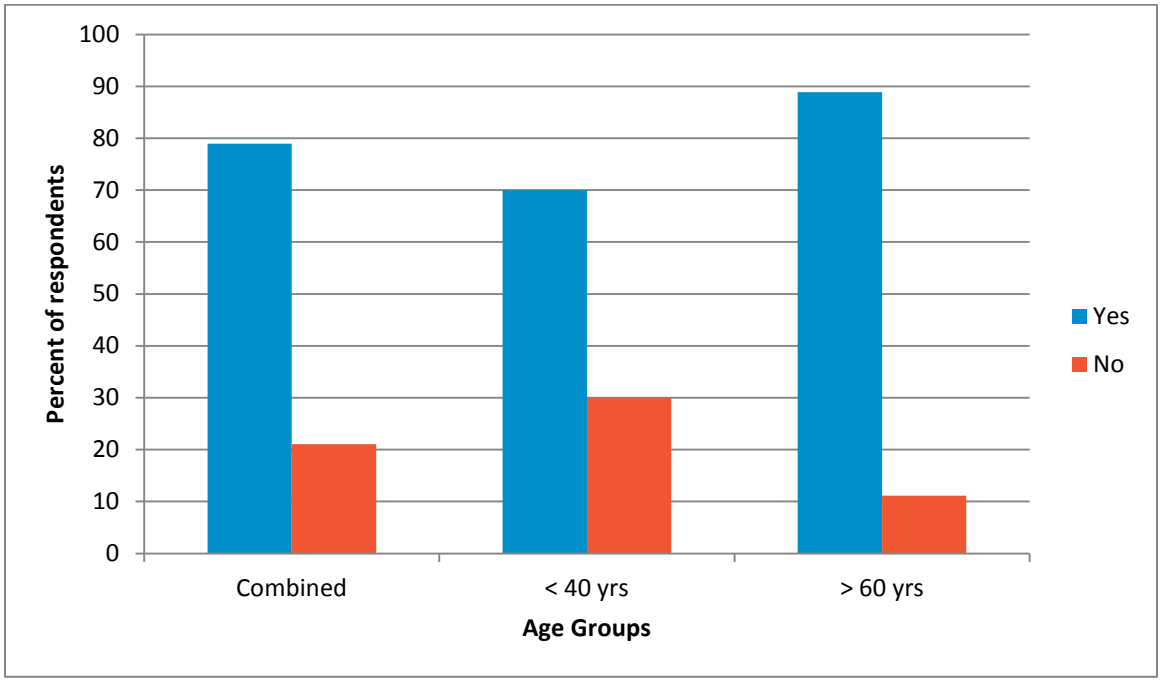

Figure 3. **Do you recognize these reflectors from previous driving experiences? (Y/N)**

If observers responded “yes” to the previous question, they were asked if the reflectors influenced how they drove in any way. Seventy-two percent of respondents who recognized the reflectors indicated that the reflectors influenced their driving in some way. Again, there was no statistically significant difference between age groups on this question (see Figure 4).

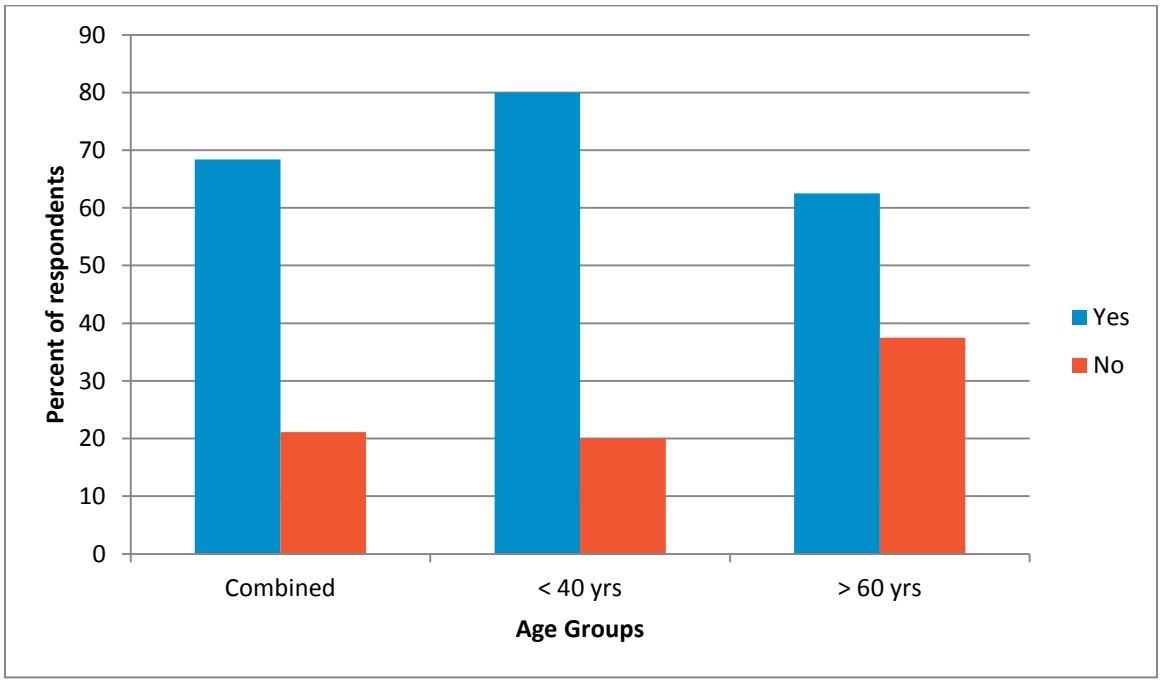

Figure 4. **Did these reflectors influence how you drove in any way? (Y/N)**

Observers who responded affirmatively to being influenced by the reflectors then indicated how the reflectors influenced their driving. Specific behaviors indicated include:

- Helped me stay in my lane (2); I try to watch them to stay in my lane.
- Helped prevent me from hitting a wall in the rain.
- I kept an appropriate speed.
- I tend not to change lanes over the reflectors, but wait to change lanes on a section of road without reflectors.

How many reflectors could you see along the road in front of you when the road was straight?

Overall, observers reported seeing a mean of 5.71 (*SD* = 3.70) reflectors along straight roadway sections. There was no statistically significant difference between age groups on this question (see Figure 5).

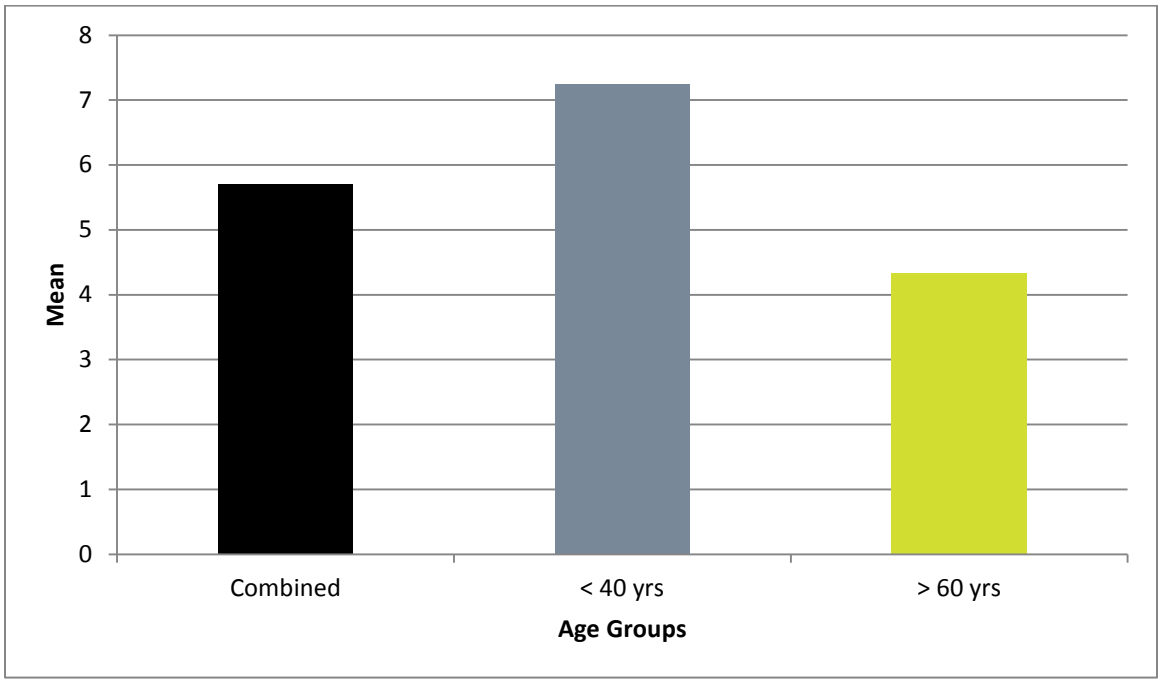

Figure 5. **Mean number of reflectors observers reported seeing on straight roads.**

Observers also reported how many reflectors they could see when the road was curved. Overall, they reported seeing 4.36 (*SD* = 3.32) reflectors on curved roads. On average, younger observers reported seeing more than twice as many reflectors as reported by older observers. Although not statistically significant,[3] this potential difference is worth noting, $t(7.44) = 2.07$, $p = .07$ (see Figure 6).

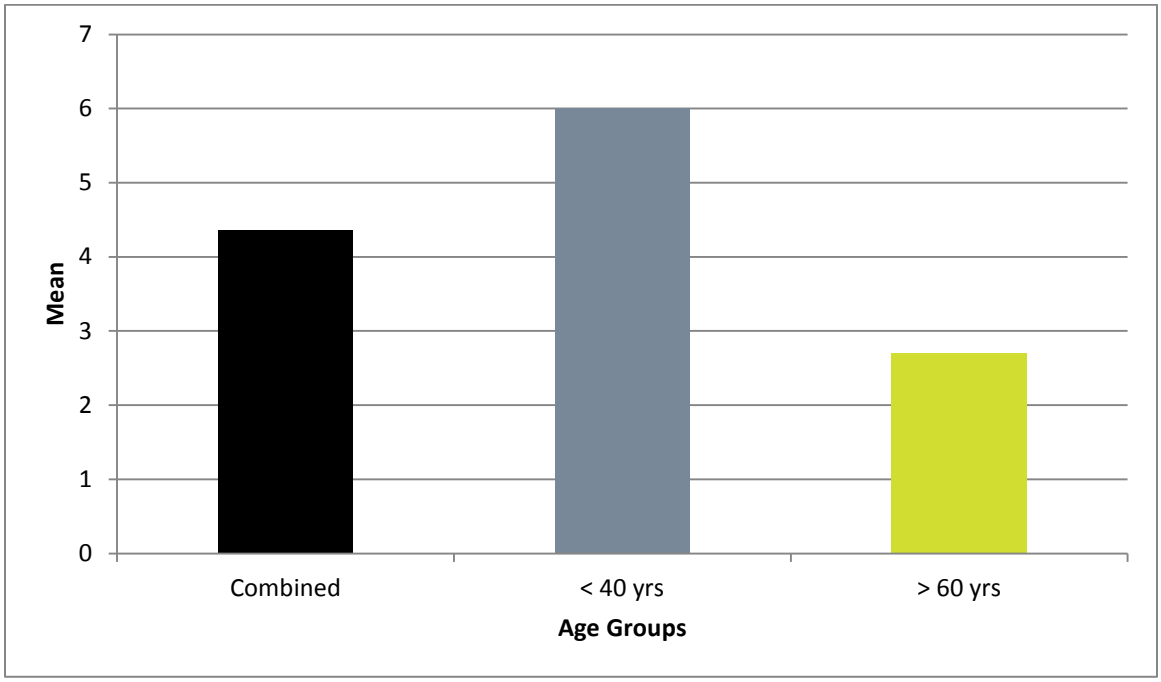

Figure 6. **Mean number of reflectors observers reported seeing on curved roads.**

Describe what you noticed about the roadway when we were driving by the reflectors compared to when we were not driving by the reflectors.

When asked to describe the roadway across reflector conditions (with vs. without), observers noted that roads with reflectors:

- "Appeared better illuminated and safer" or were "better lit and new."
- Were "easier to see." (2)
- Seemed "smoother."
- Allowed them to "focus on traffic" around them because they were "able to see the road better in peripheral vision."
- Yielded a difference when the "line paint is old or dim."

[3] We used $\alpha = .05$ as a criterion for determining statistical significance (i.e., margin of error). Probability (p) values exceeding .05 indicate that an observed difference may be the result of sampling error. In this study, differences that appear practically significant, such as the one illustrated in Figure 6, may not be statistically significant because the sample size is insufficient to provide adequate power for accurately determining actual group differences.

However, others noted there was no difference in roads with versus without reflectors, indicating:

- "No noticeable difference other than the reflectors probably help in the rain."
- "When lane stripes were fresh, reflectors were barely noticeable."
- "Very little" difference.

Do you think these reflectors help your driving at night when it is raining?

Overall, 89% of observers reported thinking that the inlaid pavement markers help their driving at night in the rain. There was no difference between age groups on this question (see Figure 7).

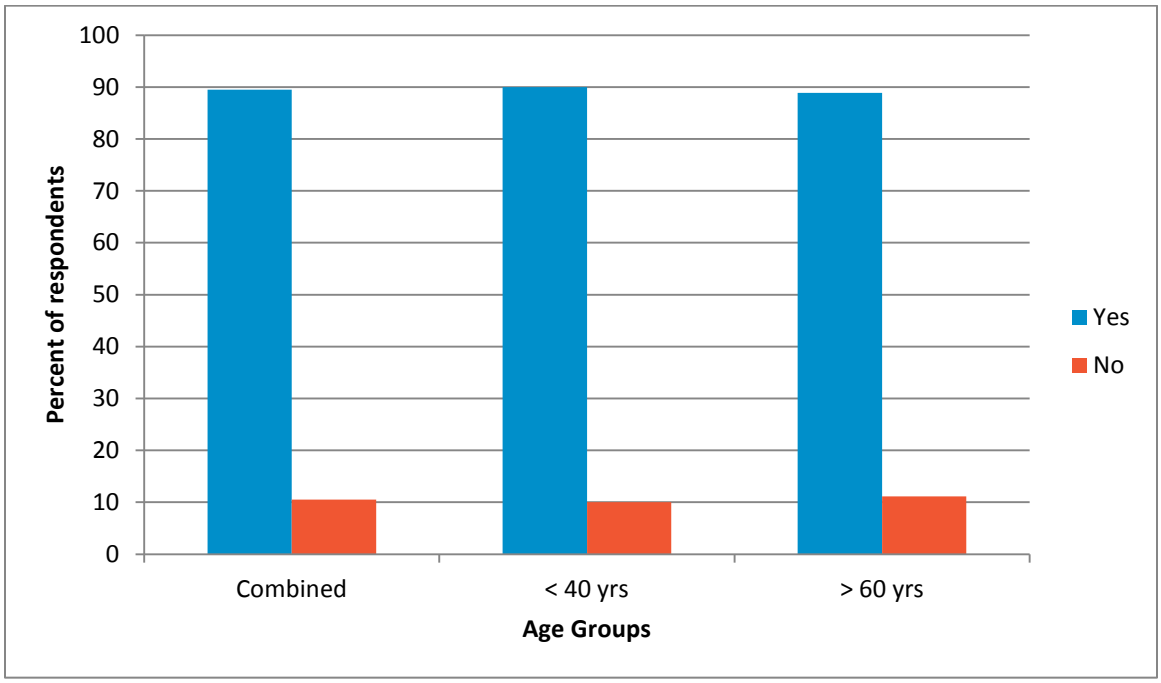

Figure 7. **Do the reflectors help your driving at night in the rain?**

Do you think these reflectors help your driving at night when it is foggy?

Overall, 74% of observers reported thinking that the reflectors help their driving at night in the fog. There was no difference in age groups on this question (see Figure 8).

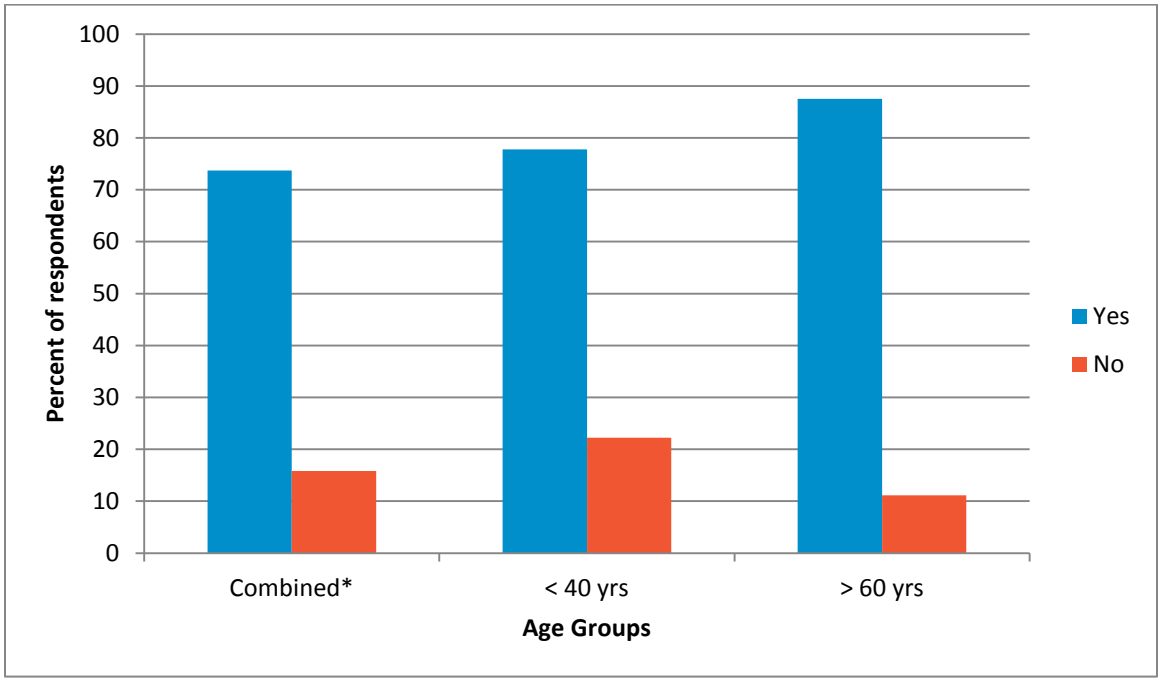

Figure 8. **Do the reflectors help your driving at night in the fog?**
Note: These data reflect two missing values and therefore do not sum to 100%.

How important is it for you to see lane markers in the rain?

This question provided a scale for responding. At the leftmost end of the scale, 1 = Not at all important, whereas at the rightmost end of the scale, 7 = Extremely important. Overall, observers indicated that it is extremely important for them to see lane markers in the rain (*M* = 6.89, *SD* = 0.32). There was no difference between age groups on this question (see Figure 9).

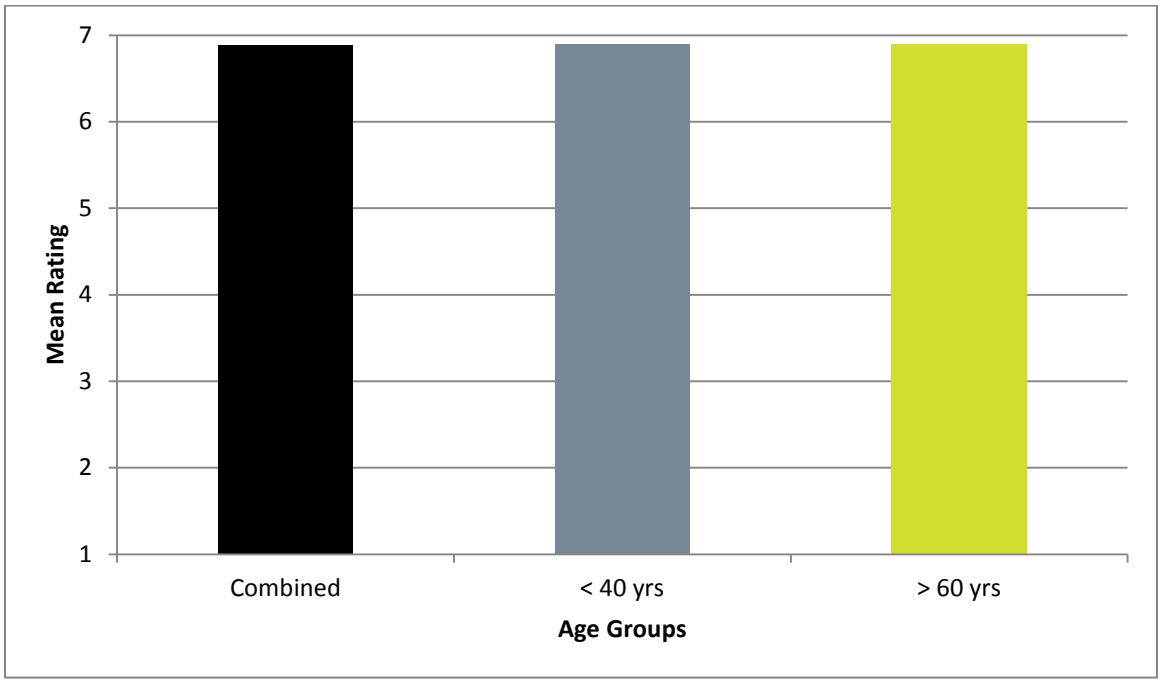

Figure 9. **How important is it for you to see lane markers in the rain?**

Do you think reflectors could hinder driving in any way?

Overall, 79% of observers did not think that the inlaid pavement markers could hinder driving in any way. There was no statistically significant difference between age groups on this question (see Figure 10). However, four observers indicated that the reflectors could hinder driving. When asked to indicate how, they suggested that:

- They could damage vehicles. (2)
- If drivers become accustomed to their placement, and placement becomes inconsistent, it could cause confusion.

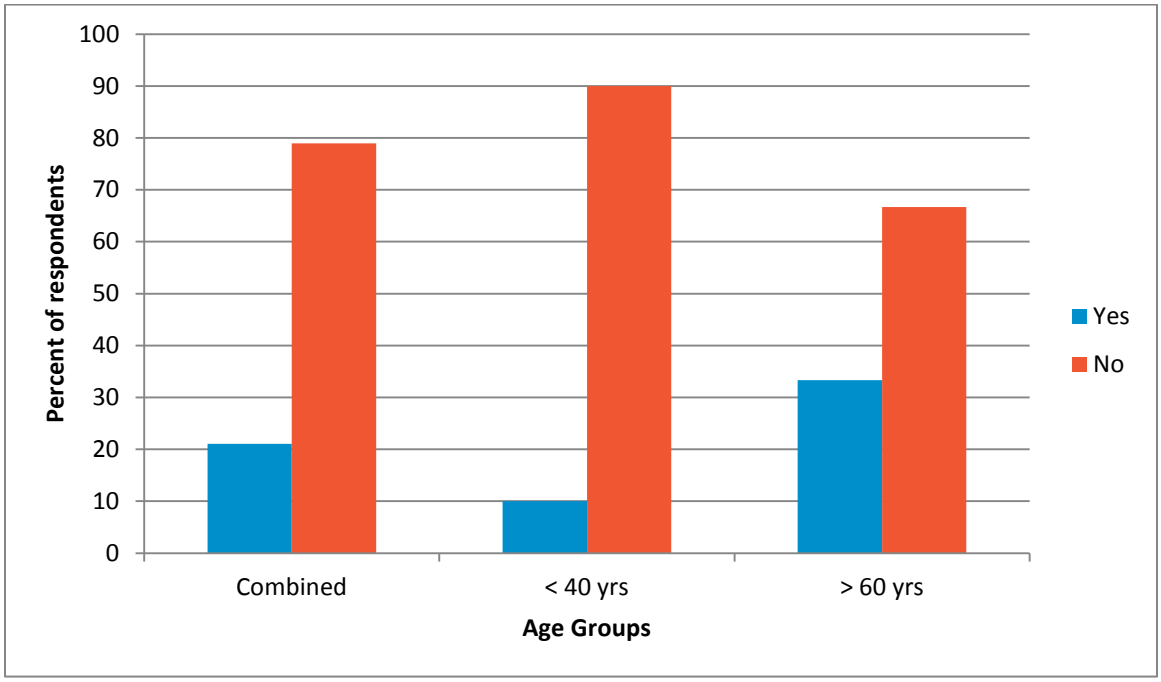

Figure 10. **Could reflectors hinder driving in any way?**

How much do the reflectors *improve* your ability to see the lane designation compared to no reflectors? (0-100%).

Overall, observers reported that the reflectors could improve their ability to see lane designations by roughly 64%. There was no difference in age groups on this question (see Figure 11).

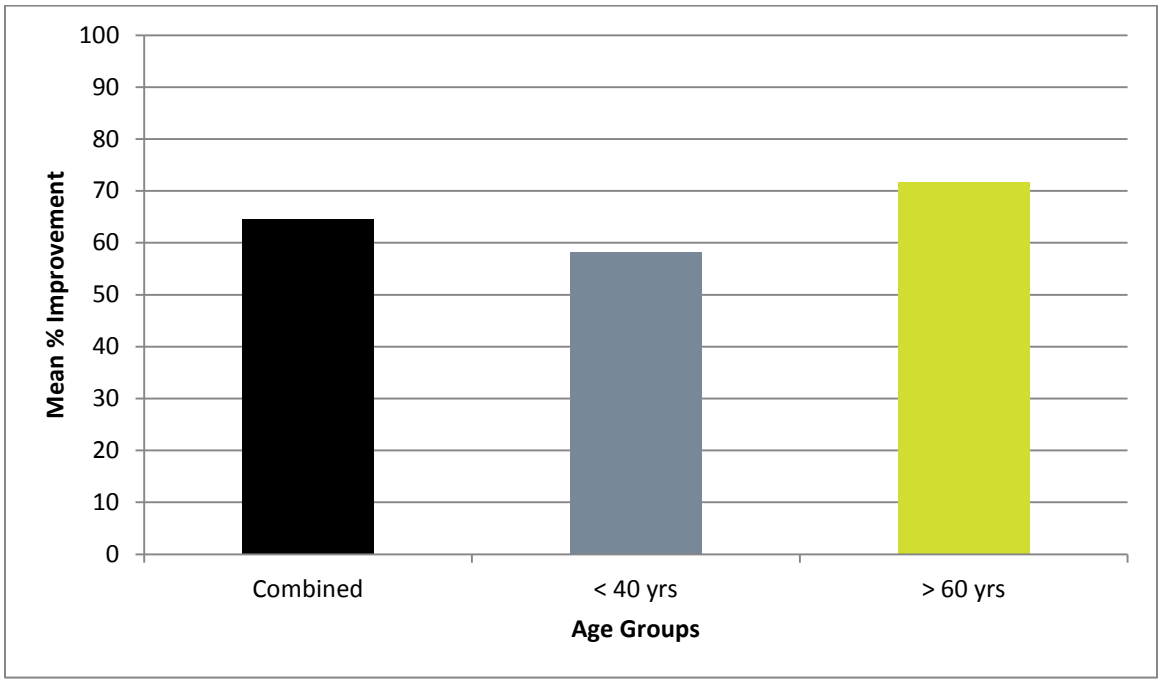

Figure 11. **How much do the reflectors improve visibility of lane designations?**

If you drive in other states, do you notice a difference in lane designations compared to Missouri?

Overall, half of observers reported noticing a difference in lane designations in other states, whereas half did not. There was no statistically significant difference between age groups on this question (see Figure 12). When asked to identify other states and how their lane designations differ from Missouri's, observers reported the following (listed in alphabetical order):

- California: Has raised markers with road surface effects; the best are in Southern California.
- Florida: Lane reflectors are huge and bright.
- Georgia: Roads in Atlanta are well lit; most interstates there are clearly marked with large reflectors that are not dirty; the lane striping is much more reflective and well maintained.
- Illinois: Lane markings are faded; don't recall reflectors; roads in Chicago are well lit.
- Indiana: Use reflectors on all roadways in Indianapolis.
- Iowa: Lane markings are more consistent.

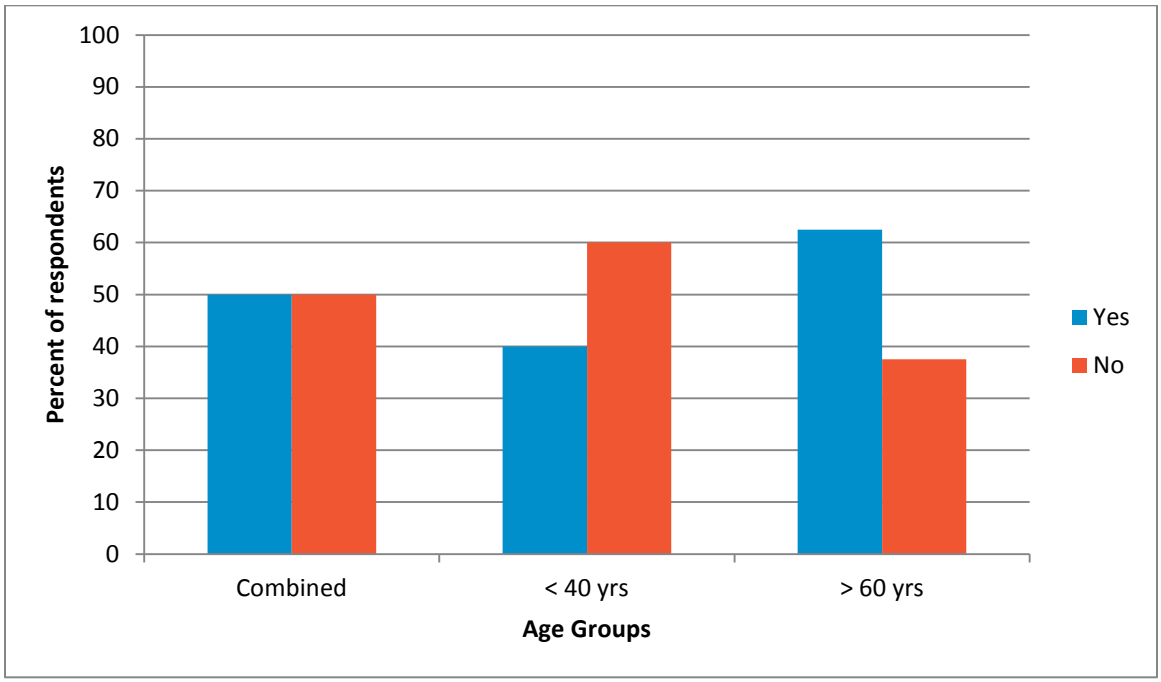

Figure 12. **Do you notice a difference in lane designation when driving in other states?**

Do you feel more or less safe while driving a route with reflectors compared to a route without reflectors?

This question provided a scale for responding. At the leftmost end of the scale, 1 = Extremely less safe, whereas at the rightmost end of the scale, 7 = Extremely more safe. Overall, observers reported feeling much more safe while driving a route with reflectors compared to a route without reflectors (*M* = 5.72, *SD* = 1.02). There was no statistically significant difference between age groups on the question (see Figure 13). When asked to report how the reflectors make them feel more or less safe, observers reported:

- Improved lane indication/designation. (14)
- Reduction in crashes. (2)
- Improved visibility in dark and bad weather. (2)

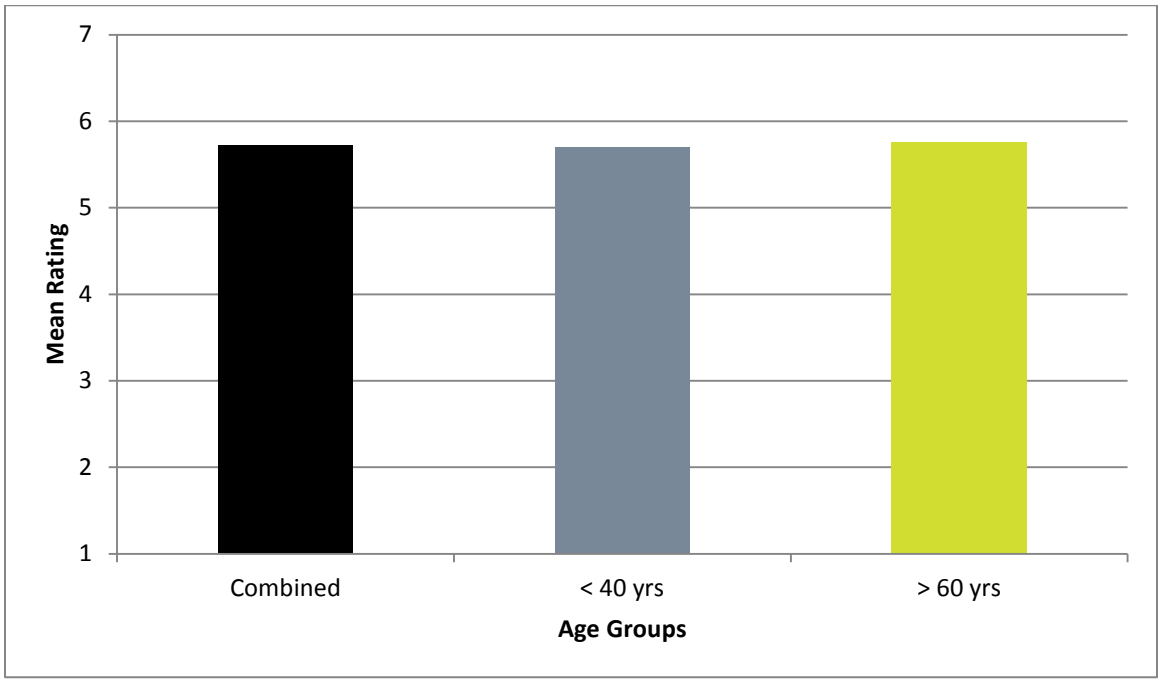

Figure 13. **Do you feel more or less safe driving routes with vs. without reflectors?**

How useful do you think it would be to have the reflectors on all roadways?

This question provided a scale for responding. At the leftmost end of the scale, 1 = Not at all useful, whereas at the rightmost end of the scale, 7 = Extremely useful. Overall, observers reported thinking that it would be extremely useful to have these inlaid pavement markers on all roadways (M = 6.67, SD = 0.59). There was no difference in age groups on this question (see Figure 14).

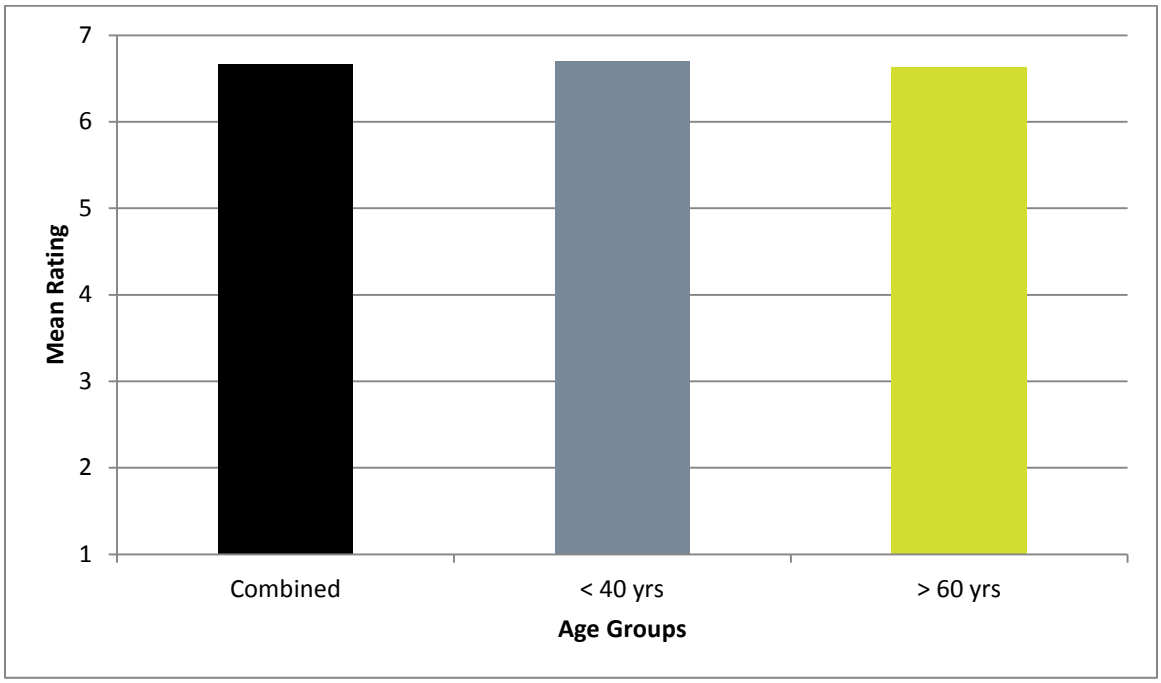

Figure 14. **How useful would it be to have these reflectors on all roadways?**

Summary

The majority of observers reported positive opinions of inlaid pavement markers, indicating that the markers make them feel safer while driving and enhance visibility, particularly in poor weather conditions such as rain and fog. Observers also reported thinking that it would be extremely useful to have inlaid pavement markers on all roadways. However, their observations of the roadways currently featuring inlaid pavement markers are mixed. They reported generally inconsistent placement of the markers in the sections they observed, but noted that proper placement of the markers improved visibility of lane designations on poorly lit roads. Generally, there were no differences in perceptions and opinions between younger observers (< 40 years old) and older observers (> 60 years old).

Chapter 3. Public Solicitation

In addition to guiding participants through observing roadways with and without inlaid pavement markers, we solicited feedback from the general public who had just exited the interstate during nighttime driving. We did this by approaching motorists, after dark, at a rest stop on I-70W, just outside of St. Louis.

Participants

Twenty motorists who had recently exited I-70W at the Wright City westbound rest stop (mile marker 199) agreed to participate in the study. Table 1 presents demographic data for these publicly solicited participants.

Table 2. ***Public Solicitation Participant Demographics.***

Mean age	50.58 (SD = 16.68)
Mean age at licensure	16.16 (SD = 1.12)
Gender	Female = 75% (n = 15) Male = 20% (n = 4) No Response = 5% (n =1)
Education	GED = 15% (n = 3) H.S. Diploma = 5% (n = 1) Some college = 15% (n = 3) Associate degree = 5% (n =1) Baccalaureate = 25% (n = 5) Advanced degree = 25% (n = 5) No Response = 10% (n = 2)
Worked in transportation	No = 50% (n = 10) Yes = 45% (n = 9) No Response = 5% (n = 1)
Highway drive hours per week	31.44 (SD = 26.47)
Years as MO resident	5.26 (SD = 12.53)
Accident resulting from road conditions	No = 90% (n = 18) Yes = 5% (n = 1) No Response = 5% (n = 1)

Note: Of the 9 participants who previously worked in transportation, 5 were truck drivers, 1 was a bus driver, 1 was a manager for a bus company, 1 was a roadway design engineer for North Carolina Department of Transportation (NCDOT), and 1 was a retired employee of Alabama Department of Transportation (ALDOT).

Materials

Questionnaire: Participants completed a questionnaire similar to the one completed by guided observation participants. The public solicitation questionnaire omitted the direct observation

questions. The demographic questionnaire included the same questions asked of the guided observation participants.

Photo: Participants viewed the same color photo of the inlaid pavement marker as was viewed by guided observation participants.

Procedure

Researchers approached motorists who entered the Wright City westbound rest stop and had exited their vehicles to walk to the onsite facilities. Researchers identified themselves as contractors for MoDOT, indicated they were conducting a study of public perceptions and observations of roadway features, and asked if the motorist had time to complete a questionnaire about roadway pavement markers. Motorists who agreed to participate viewed the photo of the inlaid pavement marker and then completed the perception/opinion and demographic questionnaires. After participants completed the questionnaires, they were thanked for their time, offered a pen or mechanical pencil as a token of appreciation, and debriefed regarding the purpose of the study. Participation lasted approximately 5-6 minutes.

Results

The following results comprise motorists' responses to the questionnaire items. They are organized by question. In addition to reporting overall results, we report differences between occupation groups (transportation vs. non-transportation).

Do you recognize these reflectors from previous driving experiences?

Overall, 95% of participants reported recognizing the reflectors from previous driving experience (see Figure 15).

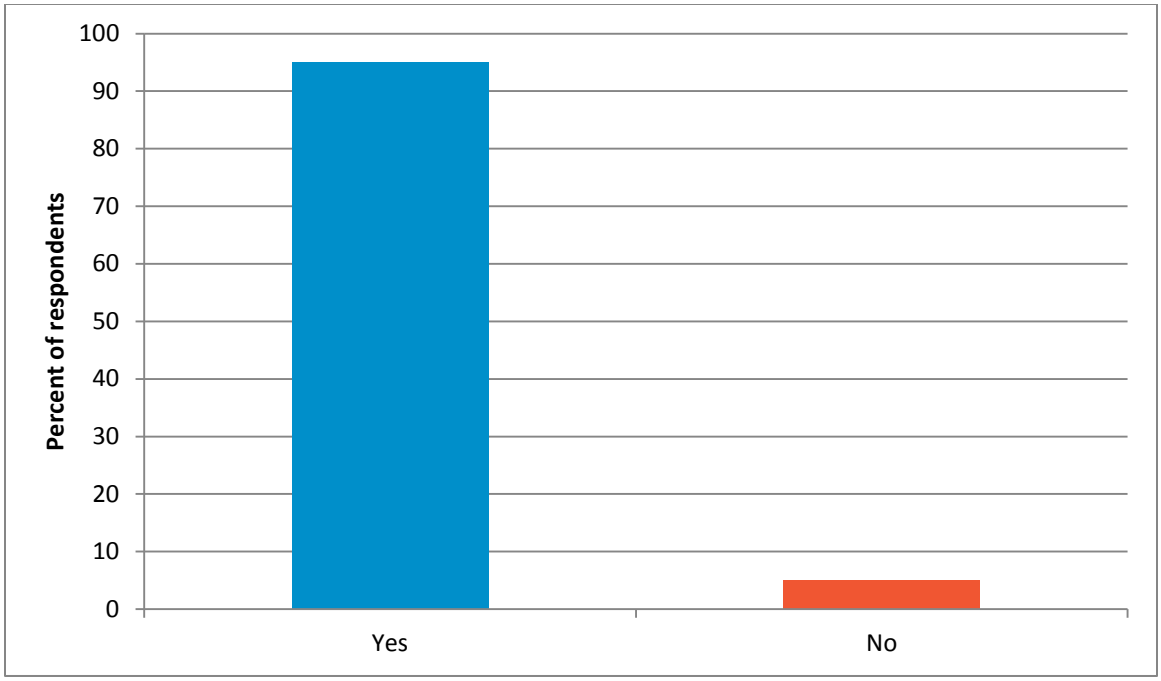

Figure 15. **Do you recognize these reflectors?**

If participants responded yes to the previous question, they were asked if the reflectors influenced how they drove in any way. Sixty-eight percent of participants who recognized the reflectors indicated that the reflectors influenced their driving in some way (see Figure 16). There was no difference between occupation groups (transportation vs. non-transportation) on this question.

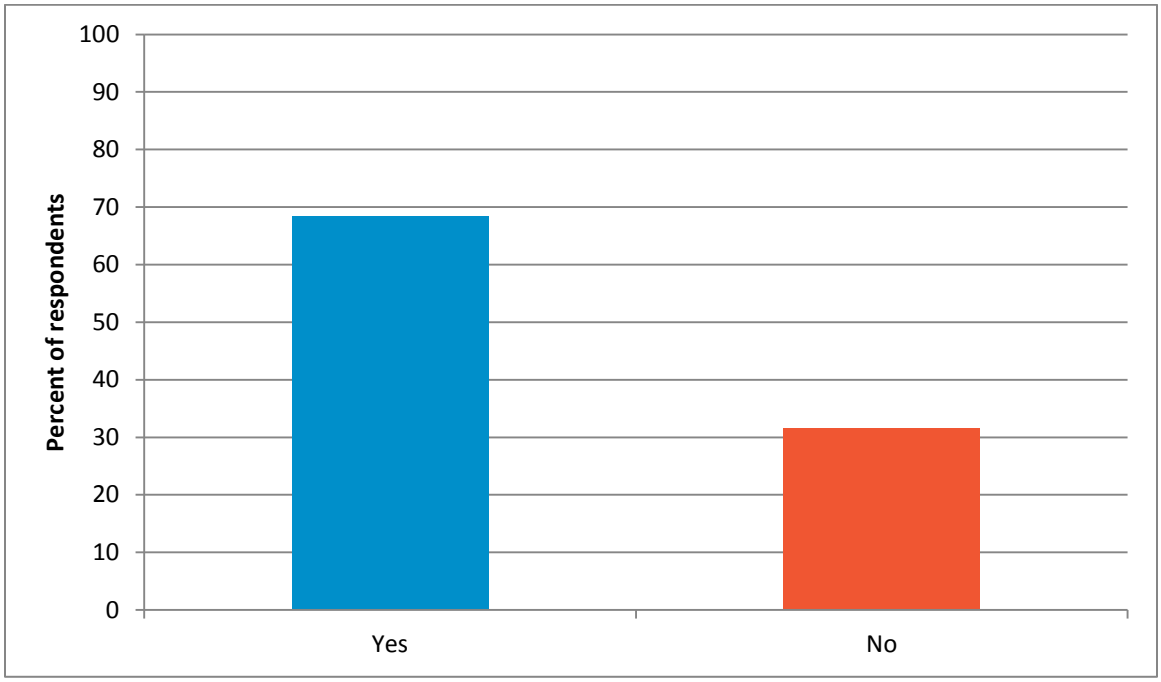

Figure 16. **Did the reflectors influence how you drove?**

Participants who indicated being influenced by the reflectors also reported how the reflectors influenced their driving. Specific behaviors indicated by participants include:

- Helped me stay in my lane. (3)
- Drove safer; improved safety overall.
- Made night/dark driving easier.(2)

Do you think these reflectors help your driving at night when it is raining?

Ninety-five percent of participants indicated thinking the reflectors help their driving at night in the rain (see Figure 17).

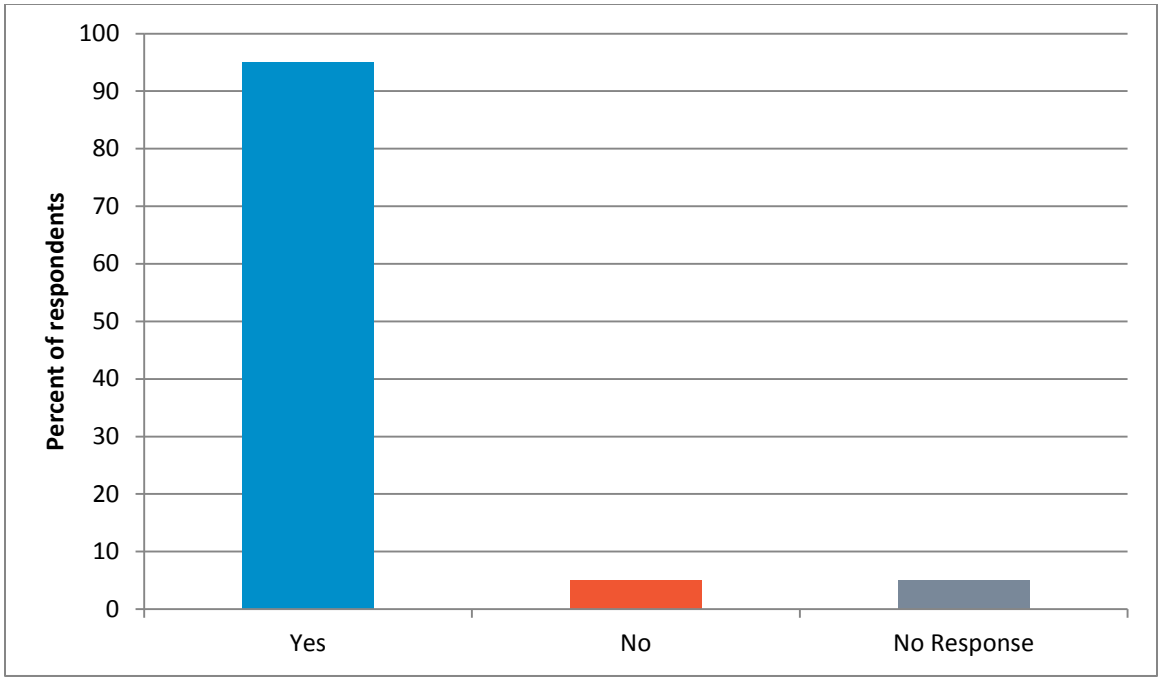

Figure 17. **Do the reflectors help your driving at night in the rain?**

Do the reflectors help your driving at night when it is foggy?

Eighty-five percent of respondents reported thinking that the reflectors help their driving at night when it is foggy (see Figure 18).

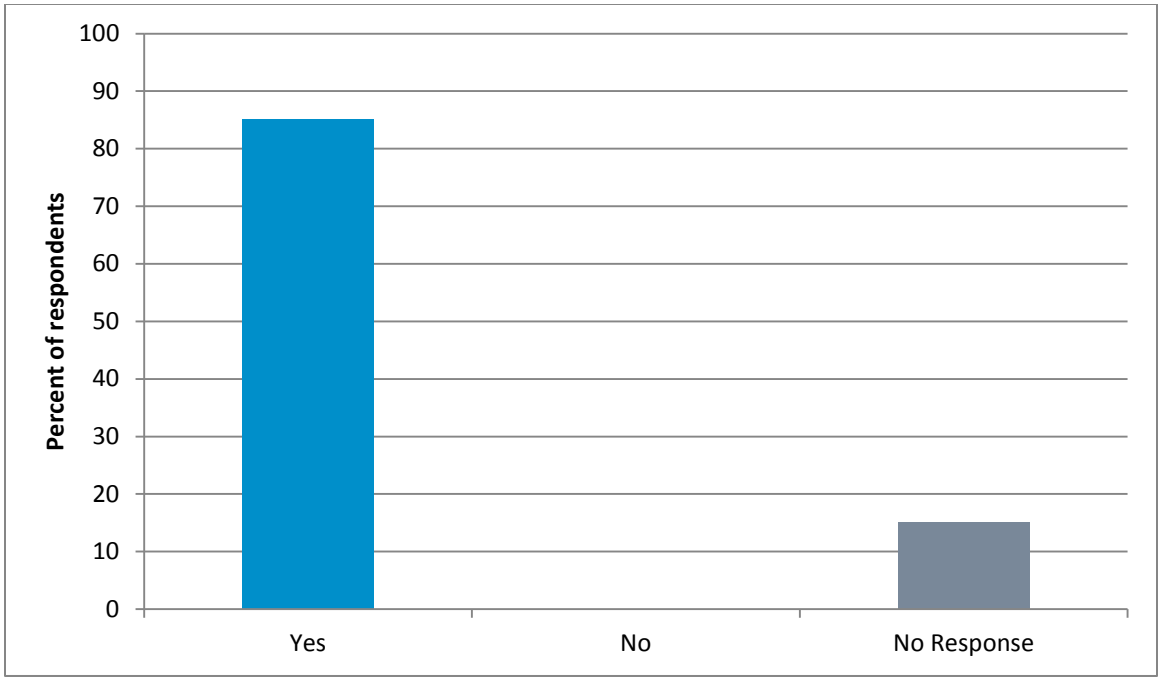

Figure 18. **Do the reflectors help at night in the fog?**

How important is it for you to see lane markers in the rain?

This question provided a scale (1-7) for responding. At the leftmost end of the scale, 1 = Not at all important, whereas at the rightmost end of the scale, 7 = Extremely important. Participants indicated that it is extremely important for them to see lane markers in the rain (*M* = 6.53, *SD* = 0.91). There was no difference in ratings across occupation groups (see Figure 19).

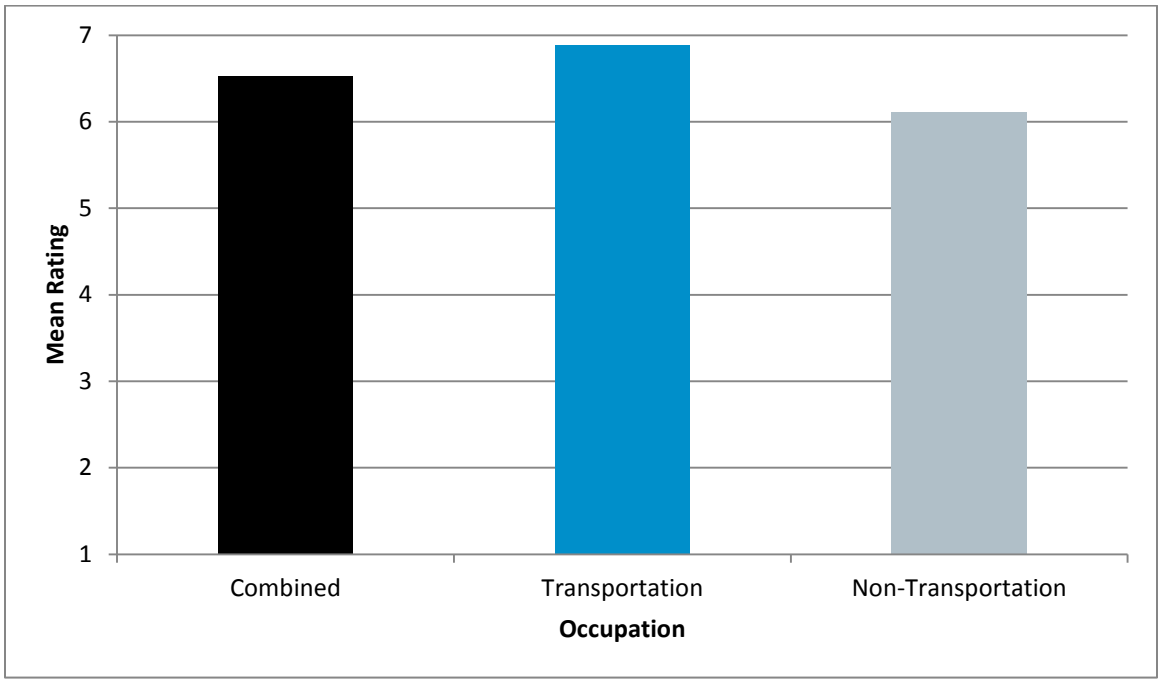

Figure 19. **How important is it to see lane markers in the rain?**

Rate how much the reflectors improve your ability to see the lane designation compared to no reflectors (0-100%).

Participants reported that the reflectors could improve their ability to see lane designations by a mean of 92.89% (*SD* = 10.45). Participants also reported that the reflectors could hinder their ability to see lane designations by a mean of 2.78% (SD = 11.79). There was no statistically significant difference between occupation groups on this question (see Figure 20).

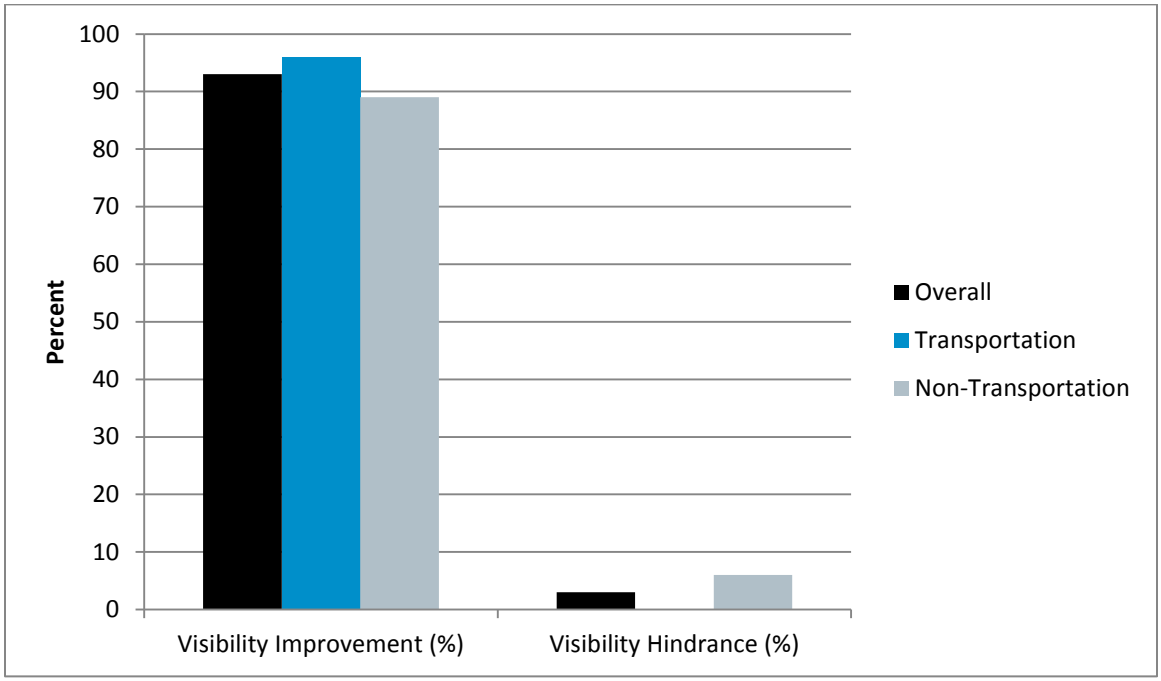

Figure 20. **Visibility improvement versus hindrance resulting from reflectors.**
Note: The transportation group reported a mean visibility hindrance of 0%.

If you drive in other states, do you notice a difference in lane designations compared to Missouri?

Overall, 60% of participants reported noticing a difference in lane designations in other states compared to Missouri (see Figure 21). There was no difference between occupation groups (transportation vs. non-transportation) on this question. When asked to identify the states where lane designations differed from Missouri's, participants reported the following (listed in alphabetical order):

- Alabama* (2)
- California
- Florida*
- Georgia* (2)
- Illinois
- Indiana*
- Iowa*
- Kentucky
- Oregon
- Tennessee* (2)
- Texas
- Virginia
- Washington

*These states were identified by participants who work or had worked in transportation.

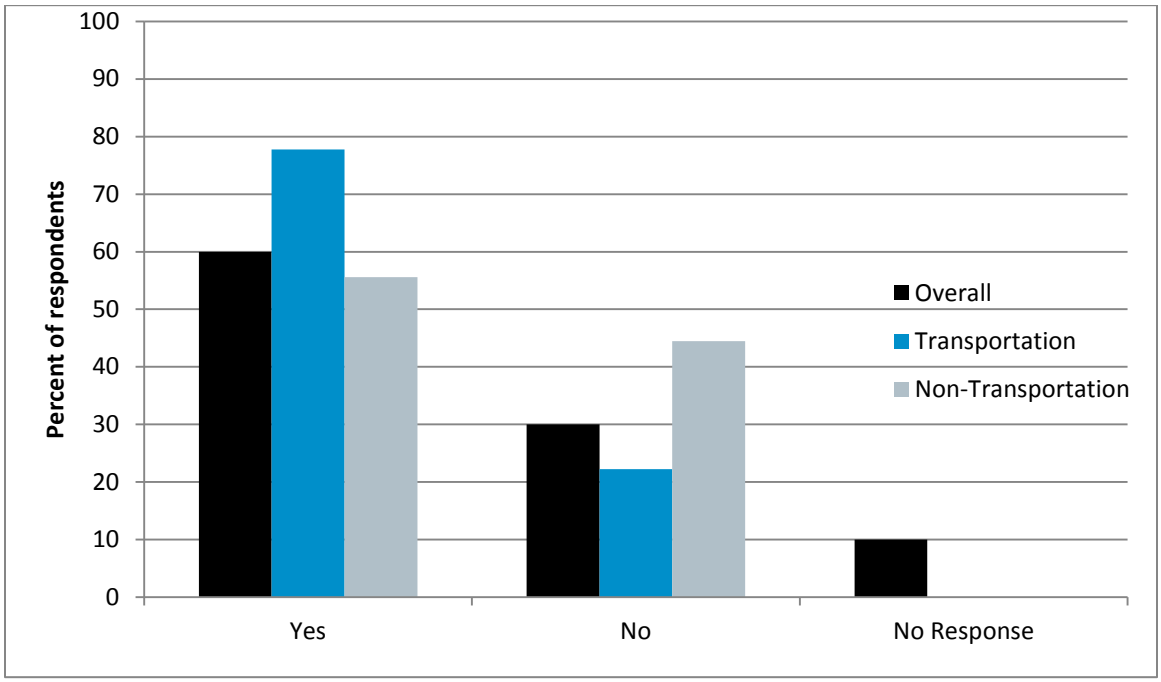

Figure 21. **Do you notice a difference in lane designation when driving in other states?**

Do you feel more or less safe while driving a route with reflectors compared to a route without reflectors?

This question provided a scale (1-7) for responding. At the leftmost end of the scale, 1 = Extremely less safe, whereas at the rightmost end of the scale, 7 = Extremely safe. Overall, participants reported feeling much more safe while driving a route with reflectors compared to a route without reflectors (M = 6.32, SD = 0.95). There was no difference between occupation groups on this question (see Figure 22).

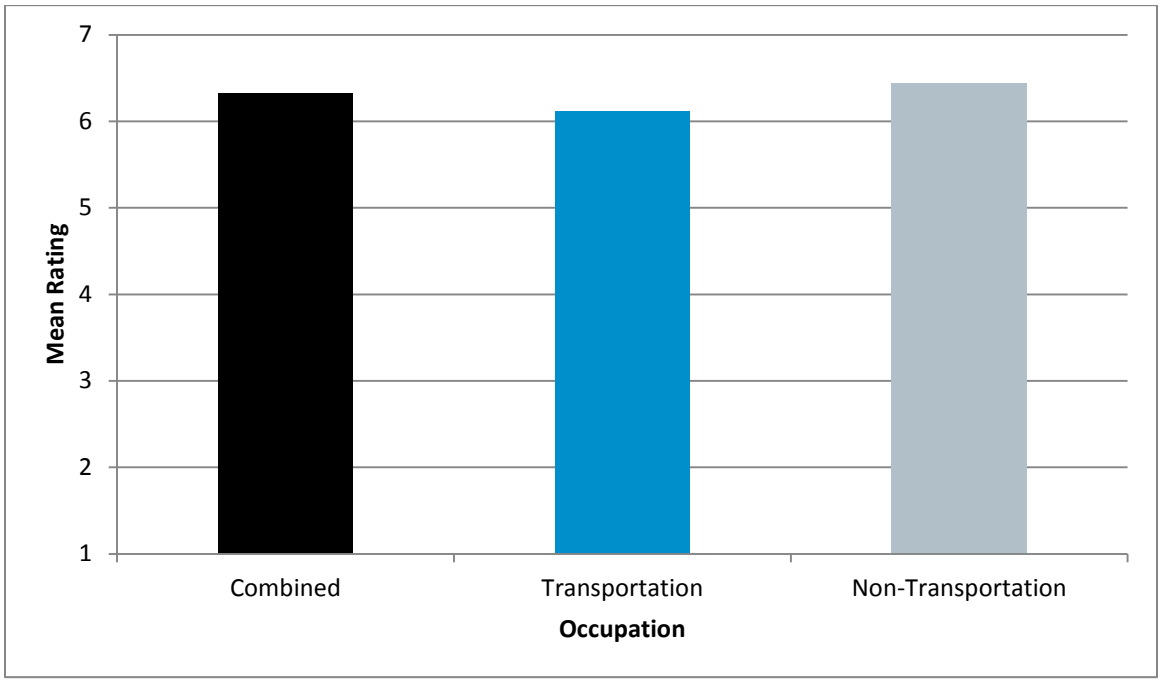

Figure 22. **Do you feel more or less safe driving routes with vs. without reflectors?**

How useful do you think it would be to have the reflectors on all roadways?

This question provided a scale (1-7) for responding. At the leftmost end of the scale, 1 = Not at all useful, whereas at the rightmost end of the scale, 7 = Extremely useful. Overall, participants reported thinking that it would be extremely useful to have these inlaid pavement markers on all roadways (M = 6.58, SD = 0.90). There was no difference between occupation groups on this question (see Figure 23).

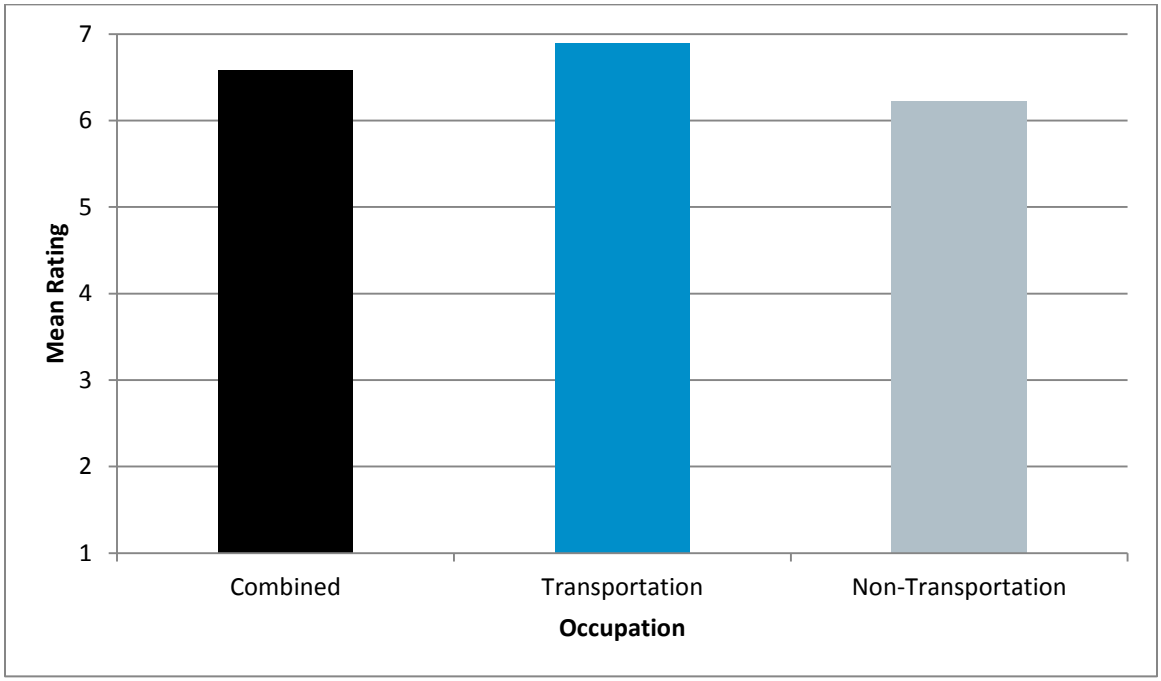

Figure 23. **How useful would it be to have the reflectors on all roadways?**

Summary

Similar to observers who experienced the inlaid pavement markers while driving in the research vehicle, publicly solicited respondents overwhelmingly reported positive opinions of the markers. They reported that the markers helped them drive safer by allowing them to see and stay in their lanes, made them feel safer while driving, and enhanced visibility in general and in poor weather conditions. These respondents also reported that it would be extremely useful to have inlaid pavement markers on all roadways. Of interest is that this sample of observers included nine individuals who either drive professionally or worked for a state department of transportation. These individuals reported the same positive opinions of inlaid pavement markers as those expressed by non-transportation participants.

Chapter 4. Law Enforcement Surveys

The third and final sample we surveyed included law enforcement personnel. We sent an e-mail to commanding officers of multiple sections of the Missouri State Police and asked them to solicit responses from State Troopers. The e-mail request included a digital photograph of the inlaid pavement marker and a hyperlink to an online survey that could be completed by troopers.

Participants

Fourteen law enforcement officers completed the online perceptions and opinions survey. Table 3 presents demographic data for respondents.

Table 3. ***Law Enforcement Demographics***

Mean age	46.57 (SD = 5.16)
Mean age at licensure	16.00 (SD = 0.00)
Gender	Female = 7% (n = 1) Male = 43% (n = 6) No Response = 50% (n =7)
Education	GED = 0% (n = 0) H.S. Diploma = 0% (n = 0) Some college = 14% (n = 2) Associate degree = 22% (n =3) Baccalaureate degree = 14% (n = 2) Advanced degree = 0% (n = 0) No Response = 50% (n = 7)
Ever worked in transportation	No = 43% (n = 6) Yes = 7% (n = 1) No Response = 50% (n = 7)
Highway drive hours per week	29.29 (SD = 6.18)
Years as MO resident	40.86 (SD = 8.88)
Accident resulting from road conditions	No = 50% (n = 7) Yes = 0% (n = 0) No Response = 50% (n = 7)

Materials

Questionnaire: Law enforcement personnel (LE) completed a similar questionnaire to those completed by public solicitation and guided observation participants. The questionnaire completed by LE participants also included questions about officers' perceptions of inlaid pavement markers' influence on other drivers' behavior and roadway safety. LE participants also completed demographic questions similar to those completed by observers and publicly solicited participants.

Photo: LE participants viewed the same color photo of the inlaid pavement marker as was viewed by all other study participants.

Procedure

The researchers prepared two 10-question surveys administered via Survey Monkey (www.surveymonkey.com). One survey solicited perceptions and opinions of the inlaid pavement markers and the other survey solicited demographic information. Because the surveys were hosted online, LE participants could access them at their convenience. Participants received an e-mail with a photo of the inlaid pavement marker, information on where the markers currently exist in roadways in and around St. Louis, and links to the online surveys. After answering all survey items by selecting from fixed choices and typing open responses, participants clicked an onscreen button to submit their completed surveys. Participation lasted approximately 5-6 minutes. Survey responses were collected and stored within the researcher's account with Survey Monkey.

Results

The following results comprise LE participants' responses to the questionnaire items. They are organized by question.

Do you recognize these reflectors from previous driving experiences?

Eighty-six percent of LE reported recognizing the reflectors from previous driving experiences (see Figure 24).

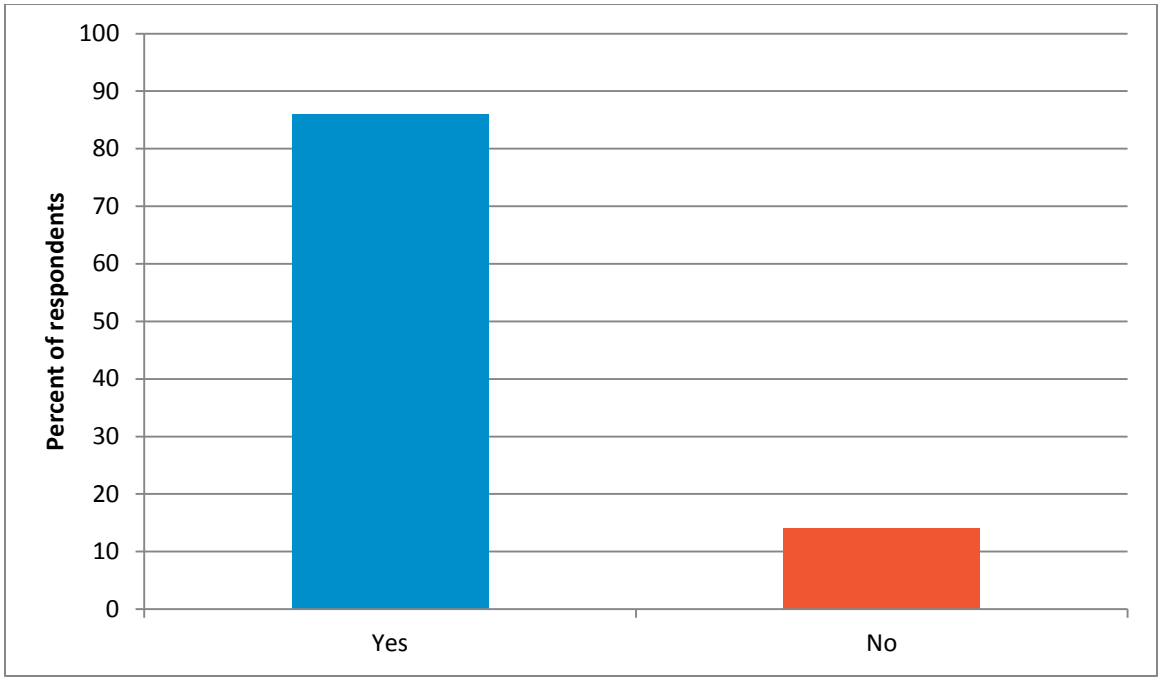

Figure 24. **Do you recognize the reflectors from previous driving experiences?**

Did these reflectors influence how you drove in any way?

Twenty-nine percent of LE reported that the reflectors influenced how they drove, whereas 64% reported that the reflectors did not influence how they drove (see Figure 25).

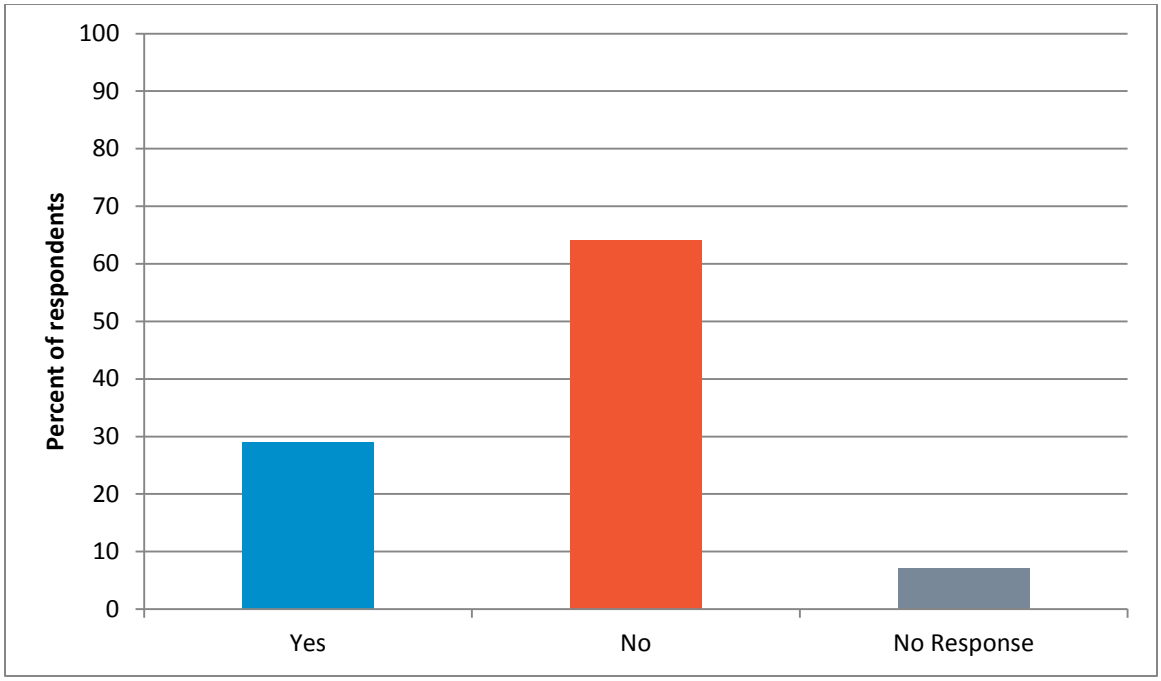

Figure 25. **Did the reflectors influence how you drove?**

Do you think the reflectors help drivers navigate lanes at night when it is raining?

Eighty-six percent of LE reporting thinking the reflectors help drivers navigate lanes at night in the rain (see Figure 26).

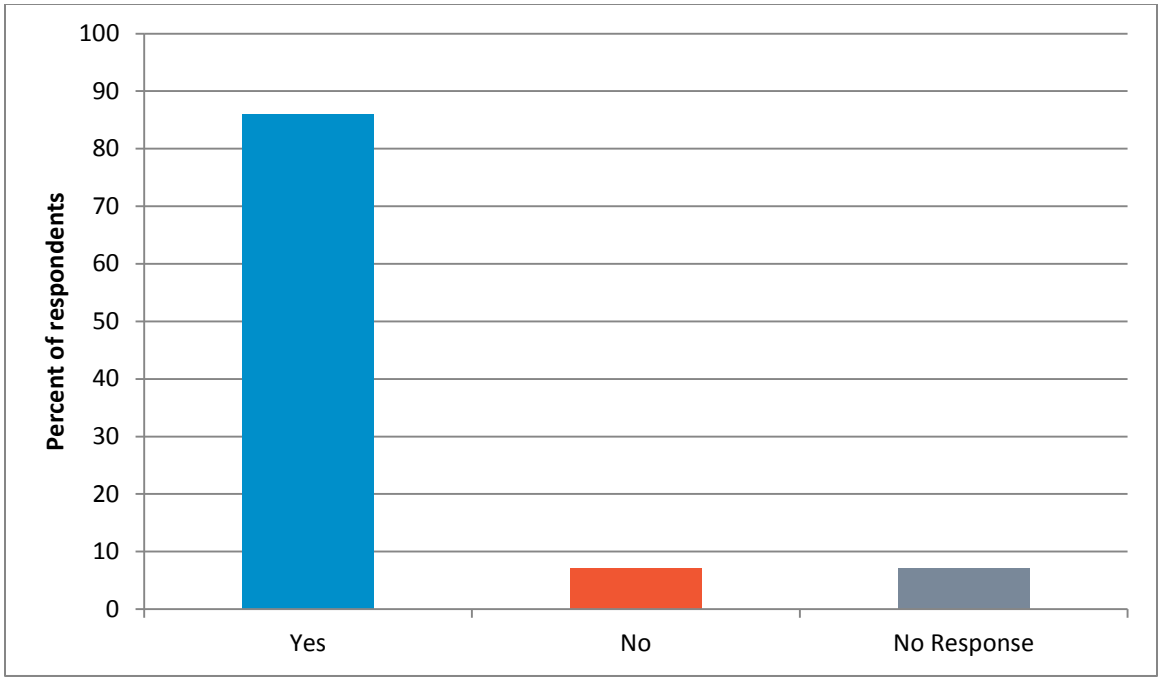

Figure 26. **Do the reflectors help drivers at night in the rain?**

Do you think the reflectors help drivers navigate lanes at night when it is foggy?

Eighty-six percent of LE reported thinking the reflectors help drivers navigate lanes at night in the fog (see Figure 27).

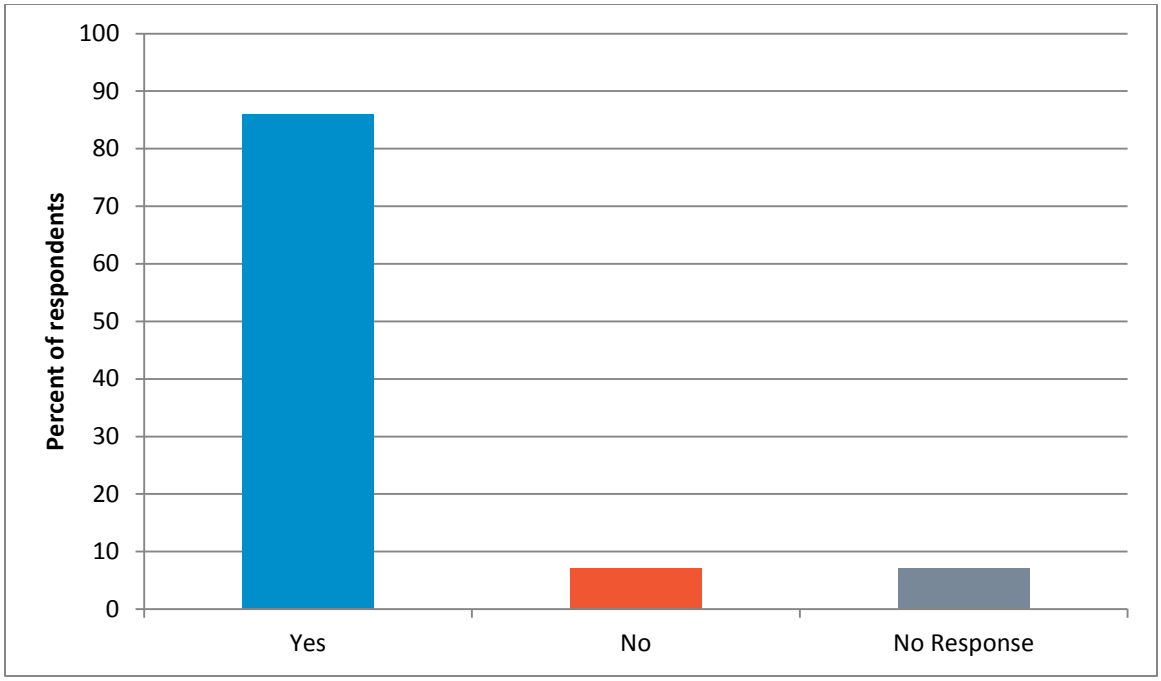

Figure 27. **Do the reflectors help drivers at night in the fog?**

In general, how much do the reflectors improve driver ability to see the lane markers compared to no reflectors?

This question asked participants to report a percent increase in driver ability to see lane markers. Law Enforcement participants reported that reflectors provide a mean of 70.83% (SD = 26.7) increase in drivers' ability to see lane markers compared to roads with no reflectors.

Describe the ways in which you think these reflectors impact driver performance:

LE participants reported the following ways in which they thought inlaid pavement markers impact driver performance:

- They "help people to stay in lane."
- Reflectors help drivers maintain their lane when visibility is restricted or poor. (4)
- The reflector "catches the eye a bit more when placed in conjunction with the normal lane lines."
- "They help people see the centerline better."
- The reflector offers a "better reference point during rain."

- "If drivers can't see the space they have to navigate in, how are they supposed to stay in the lane?"

Have you seen a decrease or increase in vehicle accidents in areas with reflectors?

This question provided a scale (1-7) for responding. At the leftmost end of the scale, 1 = Significant decrease, whereas at the rightmost end of the scale, 7 = Significant increase, and at the midpoint of the scale, 4 = Neither increase nor decrease. Fifty percent of LE participants reported seeing neither an increase nor a decrease in vehicle accidents in areas with reflectors. The mean response was 3.56 (*SD* = 1.01), corresponding with the modal response of "neither increase nor decrease."

How would you rank the durability of these reflectors against snowplows?

This question provided a scale (1-7) for responding. At the leftmost end of the scale, 1 = Not at all durable, whereas at the rightmost end of the scale, 7 = Extremely durable, and at the midpoint of the scale, 4 = Somewhat durable. Only nine participants responded to this question. The mean rating was 4.00 (*SD* = 1.73), corresponding with "somewhat durable."

How useful do you think it would be to have the reflectors on all roadways?

This question provided a scale (1-7) for responding. At the leftmost end of the scale, 1 = Not at all useful, whereas at the rightmost end of the scale, 7 = Extremely useful, and at the midpoint of the scale, 4 = Somewhat useful. Thirteen participants responded to this question, yielding a mean rating of 5.85 (*SD* = 1.52) or, on average, thinking that it would be very useful to have the reflectors on all roadways.

Summary

Similar to observers and publicly solicited respondents, law enforcement personnel reported positive perceptions and opinions of the markers. Although they indicated that the reflectors do not influence how they drive, they reported thinking that the markers helped other drivers see and stay in their lanes, particularly during poor weather and other conditions of reduced visibility. These officers also reported that it would be very useful to have inlaid pavement markers on all roadways.

Chapter 5. Conclusion

This study surveyed a diverse sample of motorists who use Missouri State highways. These motorists overwhelmingly reported favorable perceptions and opinions of inlaid pavement markers. They tended to report that the markers enhance visibility of lane delineations, particularly while driving in rain and fog, thus making them feel safer while driving. Roughly two thirds of all respondents reported that it would be "extremely useful" to have inlaid pavement markers on all roadways, with another 15% of respondents reporting that such omnipresence would be "very useful." Different groups were in general agreement on these points, as we found no differences in reporting between respondents of different genders, ages, or occupations.

When asked to report how inlaid pavement markers enhance visibility and safety, they reported that the markers improved visibility of lane delineations on poorly lit roads, allowing them to stay in their lanes and avoid accidents. Although law enforcement personnel indicated that the reflectors do not influence how they drive, they reported thinking that the markers helped other drivers see and stay in their lanes, particularly during poor weather and other conditions of reduced visibility. However, observers who experienced the inlaid pavement markers first-hand largely reported inconsistent placement of the markers in the sections they observed. Thus, it seems that respondents overall expressed favorable perceptions and opinions of the safety benefits of inlaid pavement markers, but noted that poor implementation of the markers may reduce those benefits significantly.

References

Chapanis, A. (1950). Relationships between age, visual acuity, and color vision. *Human Biology, 22*, 1-33.

National Eye Institute, National Institutes of Health. Retrieved from https://nei.nih.gov/healthyeyes/aging_eye.

Appendix A – Pavement Marker Photo

Appendix B – Guided Observation Questionnaire

Please circle the response that most applies to you or write in a detailed response. Your answers are confidential and no identifiable information will be reported. You can skip any question.

1. Did you notice these reflectors on the drive we just took (see pictures displayed by the researcher)? YES NO

   a) If so, what did you notice? _____

   _____

2. Do you recognize these reflectors from previous driving experiences? YES NO

   a) If yes, did these reflectors influence how you drove in any way? YES NO
   b) If yes, how so? _____

   _____

3. How many reflectors you could see along the road in front of you when the road was straight: _____
   a) How about when the road was curved? _____

4. Describe what you noticed about the roadway when we were driving by the reflectors compared to when we were not driving by the reflectors: _____

   _____

   _____

5. Do you think these reflectors help your driving at night when it is raining? YES NO
   a) How about at night when it is foggy? YES NO

6. How important is it for you to see lane markers in the rain? Circle a rating from 1 = not at all important to 7 = extremely important:

   1----------2----------3----------4----------5----------6----------7
   Not at all important — Extremely important

7. Do you think reflectors could hinder driving in any way? YES NO
   a) If yes, how so? _____

   _____

8. Rate how much the reflectors *improve* your ability to see the lane designation compared to no reflectors. Circle a rating from 1 = no better to 7 = extremely better:

1----------2----------3----------4----------5----------6----------7
No better Extremely better

9. If you drive in other states, do you notice a difference in lane designations compared to Missouri?

YES NO

a) If yes, describe this difference and list states: _____

_____

10. Do you feel more or less safe while driving a route with reflectors compared to a route without reflectors? Circle a rating from 1 = extremely less safe to 7 = extremely more safe:

1----------2----------3----------4----------5----------6----------7
Extremely less safe Extremely more safe

a) Describe how the reflectors make you feel more or less safe: _____

_____

11. How useful do you think it would be to have the reflectors on all roadways? Circle a rating from 1 = not at all useful to 7 = extremely useful:

1----------2----------3----------4----------5----------6----------7
Not at all useful Extremely useful

Appendix C – Public Solicitation Questionnaire

Please circle the response that most applies to you or write in a detailed response. Your answers are confidential and no identifiable information will be reported. You can skip any question.

1. Do you recognize these reflectors from previous driving experiences (see pictures displayed by the researcher)? YES NO

a) If yes, did these reflectors influence how you drove in any way? YES NO
b) If yes, how so? _____

2. Do you think these reflectors help your driving at night when it is raining? YES NO
   a) How about at night when it is foggy? YES NO

3. How important is it for you to see lane markers in the rain? Circle a rating from 1 = not at all important to 7 = extremely important:

   1----------2----------3----------4----------5----------6----------7
   Not at all important — Extremely important

4. Rate how much the reflectors *improve* your ability to see the lane designation compared to no reflectors. Provide a number from 0% better to 100% better: _____

5. Rate how much the reflectors *hinder* your ability to see the lane designation compared to no reflectors. Provide a number from 0% worse to 100% worse: _____

6. If you drive in other states, do you notice a difference in lane designations compared to Missouri?

   YES NO

a) If yes, which states? _____

7. Do you feel more or less safe while driving a route with reflectors compared to a route without reflectors? Circle a rating from 1 = extremely less safe to 7 = extremely more safe:

   1----------2----------3----------4----------5----------6----------7
   Extremely less safe — Extremely more safe

8. How useful do you think it would be to have the reflectors on all roadways? Circle a rating from 1 = not at all useful to 7 = extremely useful:

   1----------2----------3----------4----------5----------6----------7
   Not at all useful — Extremely useful

Appendix D – Online Questionnaire

1. Do you recognize these reflectors from previous driving experiences (refer to image sent with survey link)? YES NO

2. Did these reflectors influence how you drove in any way? YES NO

3. Do you think the reflectors help drivers navigate lanes at night when it is raining?

   YES NO

4. Do you think the reflectors help drivers navigate lanes at night when it is foggy?

   YES NO

5. In general, how much do the reflectors improve driver ability to see the lane markers compared to compared to no reflectors (provide a number from 0% better to 100% better)?

   [ ]

6. Describe the ways in which you think these reflectors impact driver performance:

   [ ]

7. Have you seen a decrease or increase in vehicle accidents in areas with reflectors?

   1----------2----------3----------4----------5----------6----------7
   Significant decrease — Neither increase nor decrease — Significant increase

8. Have you noticed a difference in driver behavior or accidents on roads with reflectors under various weather conditions? YES NO

9. How would you rank the durability of these reflectors against snowplows?

   1----------2----------3----------4----------5----------6----------7
   Not at all Durable — Somewhat durable — Extremely durable

10. How useful do you think it would be to have the reflectors on all roadways?

    1----------2----------3----------4----------5----------6----------7
    Not at all useful — Extremely useful

Appendix E – Demographic Questionnaire

Please circle the response that most applies to you or write in a detailed response. If the question does not apply to you, please write N/A. Your answers are confidential and no identifiable information will be reported. You can skip any question.

1) *At what age did you get your driver's license?* _____

2) *Current age:* _____

3) *Gender:* Male Female

4) *Describe any vision issues you have that might influence your ability to see roadway features such as roadway signs and pavement striping:* _____

_____

5) *Education level:* GED High School Trade School Some College

Associates Degree Bachelor's Degree Advanced Degree

6) *Occupation:* _____

7) *Have you ever worked in the transportation industry?* YES NO

If yes, please describe: _____

8) *Estimate the average number of hours you drive on the highway per week:* _____

9) *How many years have you lived in Missouri?* _____

10) *Have you ever been in an automobile accident that you attributed to poor roadway viewing conditions?* YES NO

If yes, please describe the conditions: _____

_____

_____

Appendix F – Recruitment Advertisement

Adult highway drivers in the St. Louis, MO area needed for a transportation study.

The Missouri Department of Transportation (MoDOT) is seeking individuals in the St. Louis area who:

- Have a valid U.S. driver's license
- Are between the ages of 18-30 or are at least 60 years old
- Regularly drive on highways in Missouri or other states

Estimated participation time is 2 hours
Compensation is $30
Your data will be kept confidential

If interested, please contact Applied Research Associates at HighwayStudy@ara.com