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16. Abstract Past research assessing sign comprehension has often employed methodologies such as simple, self-paced paper and pencil tests that ask "what do you think this sign means?" These studies often fail to detect any improvement in comprehension from one sign to another, newly designed version of the same sign. This experiment evaluated the effectiveness of different display methods to assess traffic sign comprehension. While a driving simulator allows fine measurements of driving performance, it is an expensive and inconvenient way to present signs for a simple multiple choice comprehension test. One of the aims of this study was to identify less expensive and more portable methods of testing sign comprehension. Different sign designs were compared which indicated freeway-to-freeway splits, lane drop exits, and left exits. A sign comprehension test was administered via the following methods: 1) Self-paced paper and pencil test of images of signs in a road context; 2) Self-paced paper and pencil survey of images of signs in isolation; 3) Limited exposure time computer presentation of the signs in road context; 4) Limited exposure time computer presentation of the signs in isolation; 5) Video loop of a driving scene generated by driving simulator software presented in a classroom; and 6) Fully interactive driver-in-the-loop presentation of the signs in appropriate roadway scenes in a wrap-around simulator. Results showed that for simple bold messages, the time-limited presentation media all performed similarly. The video presentation seemed to suffer some clarity reduction for text-heavy guide signs. The self-paced paper tests, as used in much previous work, showed higher comprehension scores for certain sign types.					
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3D VISUALIZATION AS A TOOL TO EVALUATE SIGN COMPREHENSION

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ABSTRACT

Past research studies assessing sign comprehension have often employed methodologies such as simple, self-paced paper and pencil tests that ask “what do you think this sign means?”

These studies often fail to detect any improvement in comprehension from one sign to another, newly designed version of the same sign. This experiment evaluated the effectiveness of different display methods to assess traffic sign comprehension. While a driving simulator allows fine measurements of driving performance, it is an expensive and inconvenient way to present signs for a simple multiple choice comprehension test. One of the aims of this study was to identify less expensive and more portable methods of testing sign comprehension. Different sign designs were compared which indicated freeway-to-freeway splits, lane drop exits, and left exits. A sign comprehension test was administered via the following methods: 1) Self-paced paper and pencil test of images of signs in a road context; 2) Self-paced paper and pencil survey of images of signs in isolation; 3) Limited exposure time computer presentation of the signs in road context; 4) Limited exposure time computer presentation of the signs in isolation; 5) Video loop of a driving scene generated by driving simulator software presented in a classroom; and 6) Fully interactive driver-in-the-loop presentation of the signs in appropriate roadway scenes in a wrap-around simulator. Results showed that for simple bold messages, the time-limited presentation media all performed similarly. The video presentation seemed to suffer some clarity reduction for text-heavy guide signs. The self-paced paper tests, as used in much previous work, showed higher comprehension scores for certain sign types.

EXECUTIVE SUMMARY

The present study demonstrates that sign comprehension can be tested using an inexpensive and portable method which produces results similar to those found in an interactive driving simulator. These results enable future studies of sign comprehension to be conducted across a wider geographic and demographic area; to be prepared more quickly and less expensively; and for data to be collected in less time.

The study compared sign comprehension between groups of participants who were shown signs in one of six ways:

1. dynamically in a road context in an interactive driving simulator;
2. dynamically watching a videotape of the driving simulator;
3. viewing still images for a limited time on a computer screen of signs pulled from the driving simulator road context;
4. viewing still images for a limited time on a computer screen of signs in isolation;
5. viewing still images for an unlimited time on paper of signs in road context;
6. viewing still images for an unlimited time on paper of signs in isolation.

The results show that performance in the dynamic viewing conditions (1 & 2) produced similar results as viewing still images for a limited time (3).

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DISCLAIMER

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INTRODUCTION

Researchers are faced with the issue of selecting the most appropriate experimental method early in every project. For studies assessing sign comprehension, the methods can range from a simple, self-paced paper and pencil test that asks “what do you think this sign means ?” to field observations of actual traffic after installation of a new sign. The researcher must consider the time and money available to do the study, as well as the likely sensitivity of each method, in making a selection. Researchers can vary the nature of the comprehension assessment, for example, by using multiple choice tests or asking subjects for a verbal explanation of each sign. They could also vary the way the test is administered. Stimuli presentation time can be controlled by the experimenter or the subject. The stimuli themselves could be simple line drawings of signs, or photographs of actual signs on the road, or computer generated signs in a driving simulator. Each of these factors will affect the sensitivity of measurements and the generalizability to the real driving task.

Conceptually, true comprehension would evidence itself by the driver executing the correct driving maneuver at the correct place and time for signs which require maneuvers. True comprehension of warning and guide signs would occur when a driver updates his or her awareness of the driving environment to include pieces of knowledge relevant to the particular driving task. Comprehension is not the same as memory. Comprehension is a more fleeting moment; signs that are comprehended may be committed to memory if important. So, for instance, a warning sign about potential ice on the road could be read and understood but quickly purged from memory during August. Likewise, destinations and distances on a guide sign can be comprehended but not recalled later if they were not pertinent to a driver’s route. Another important conceptual issue concerns assumptions about the nature of comprehension. Is it a binary concept where either “you get it or you don’t”? Or, is comprehension a linear concept where there can be varying degrees or depths of comprehension. Certainly, in the larger field of reading comprehension, the basic conception is one of depth or degree. A reader of literature can comprehend the writing at various levels (Just & Carpenter, 1987). But can the same be said of something as simple as a traffic sign? Comprehension of certain messages, such as STOP, could be considered binary.

Comprehension is not the same as memory, and it also isn't the same as reading or legibility. It is certainly possible for someone to be able to read the words or describe the symbols on a sign and not comprehend it at all or to misinterpret it. The technology exists to track the eye movements of a person driving a car. This equipment can tell a researcher that a driver looked at a sign. It cannot tell the researcher if the subject read the sign, comprehended the sign, or remembers the sign. The technology also exists to measure the reading time of a sign in a laboratory setting. A researcher could make the assumption that reading time is correlated to comprehension such that the longer the reading time, the harder the sign is to comprehend. Without some independent test, reading time alone is not a sufficient measure of comprehension. Though subjects may have been instructed to "press the button when you're sure you understand the sign", there is no guarantee that the subjects actually did comprehend the signs.

The challenge for researchers is to access this private state of "comprehension" using methods which give every chance for subjects to display their comprehension while limiting the opportunity for guessing at the right answer when true comprehension has not occurred.

Many past research studies assessing traffic sign comprehension have employed self-paced paper and pencil tests that essentially ask "what do you think this sign means?" This question is often followed by a multiple choice answer. Multiple choice tests allow easy scoring, especially when compared to an open-ended question which requires the development and application of scoring criteria. Consistently applying the criteria to responses is difficult, as is achieving good inter-rater reliability. Scoring verbal or written responses is much more time-consuming, and thus expensive, than multiple choice tests. The challenge of multiple choice tests for the experimenter comes in creating the alternative responses. The possible choices need to be worded in a similar way and include all possible interpretations of each sign. If the false alternatives are too easily spotted, subjects could guess the right answer based on characteristics of the response set not based on actual comprehension of the sign. Careful pre-testing of potential multiple choice alternatives is required to equate difficulty and reduce chance performance. Multiple choice tests that are not pre-tested could produce comprehension scores which are inflated relative to the true comprehension.

Past studies employing self-paced multiple choice questions often produce comprehension rates well over 85 % for both standard and proposed signs under evaluation (e.g. McNees and Messer, 1981; Hawkins, Womack and Mounce, 1995). This either means that

nearly all drivers understand all signs or that something about the study protocol inflated the true comprehension levels. When performance on all questions is this high the test becomes insensitive to differences across items; behavioral scientists refer to this as a ceiling effect. These ceiling effects also prevent detection of any comprehension differences between alternate versions of the same sign. Self-paced studies may be providing subjects an unrealistically long period of time to view the candidate signs. In actual driving environments, road signs are typically within legibility range for only 3-5 seconds, depending on speed. Another unrealistic aspect of past paper and pencil tests is that the signs were typically shown in isolation, not in a roadway environment. Seeing a sign in an appropriate context could help comprehension.

There appears to be a cost vs. realism tradeoff in this field of research. Wherein, the less expensive a method is, the less it effectively captures the realism of the driving experience. Given the relatively high correct response rates associated with most sign comprehension studies which use simple line drawings or photographs of signs, it is possible that deficiencies in realism associated with the methods are artificially inflating scores. Therefore, a method that depicts the actual driving experience more realistically may provide a more accurate measure of the true population comprehension levels of road signs. The DriveSafety™ Driving Simulator at the Texas Transportation Institute provided a unique opportunity to assess the costs and benefits of realistic, 3D full-immersion technology against an array of the more common methods.

The disadvantages of the driving simulator are the cost and its fixed location. The experimental subjects are generally drawn from the local community which narrows the demographics and driving experience of the research sample. If a method could be found which produces images and cognitive loads similar to those found in the simulator, but which is portable and less expensive, a wider variety of subjects could be tested. In addition, a paper or laptop computer based test could be administered to multiple participants simultaneously, thus reducing overall data collect time and expense. The cost of preparing an experiment in the simulator is also relatively high and requires some programming experience with the system.

The purpose of the current study was to investigate sign comprehension across different methodologies. The same diverse selection of 12 warning and guide signs were used in each of the six experimental methods. Important consideration is given to the stimulus presentation time and the quality of the image of the traffic sign across the methods that are used in sign comprehension studies. The present research study made a calculated effort to select signs that

had been utilized in previous research to facilitate congruent comparisons. For this same reason, the questions and response options were also derived from previous research studies.

The present study consisted of sign comprehension method comparisons across six independent conditions involving four larger method categories: Driving Simulator, Video, PowerPoint Slide Show, and Pencil-and-Paper methods. The PowerPoint Slide Show and Pencil-and-Paper methods were each divided into two conditions that presented the sign stimuli either in isolation or within a roadway context. The sign stimuli were identical across all methods.

DEVELOPMENT OF STUDY PROTOCOL

Sign Reading Time Background Research

Zwahlen and Schnell (2000) conducted a study investigating drivers' looking times at freeway traffic signs. The study was conducted with participants on actual roadways using an experimental vehicle and specialized eye scan equipment. The 'first' and 'last' looks as a driver is approaching a sign are important because they are an indication of when and at what distance a driver begins and ceases, respectively, extracting visual information from the target sign (Zwahlen & Schnell, 2000). The authors found that, across all signs tested, the overall median first look was at a distance of 123 meters and the overall median last look distance was 48 meters prior to the sign. The implication is that a typical sign is detected and read 48 and 123 meters prior to reaching the sign. At a constant rate of speed of 60mph, the driver would have approximately 3 seconds to detect and read the sign on approach.

Zwahlen and Schnell's (2000) study of driver looking times has further implications regarding the experimental testing methods of sign comprehension. Given that the drivers in the study focused on the sign and then looked away an average of 2.82 times, it is implicit that they did not hold a visual fixation on the sign during the entire interval the sign was visible and legible. This is presumably because they were simultaneously devoting attention to the actual task of driving. This suggests that research methods that simply display sign stimuli (e.g., static hardcopy or projected visual stimuli in lab environments) without requiring the cognitive processing of other information (e.g., lane tracking, road hazards, being vigilant of surrounding traffic, etc.) not only fail to capture the richness of the driving experience, but do not accurately account for the cognitive load required under actual or simulated driving conditions. Moreover, studies involving static sign stimuli removed from the driving situation may not accurately reflect the true processing time available for drivers, or the lack thereof. The implication for the present study is that unlimited exposure time for sign stimuli displayed in hardcopy or projected formats may allow participants to focus exclusively on the stimuli without contemporaneous attention demands. Consequently, in situations of actual or simulated driving, sign stimuli would need to be displayed for relatively greater exposure times in order to provide more equivalent comparisons across methods.

McNees and Messer (1981) argue that the time a driver has available to read and process sign message information is only a portion of the total time a sign is visible. The reading time is less than the total static legibility time, which is less than the visibility time. This is due to the fact that drivers must ‘time-share’ reading signs with other driving tasks, such as lane tracking and being alert to surrounding traffic. The authors estimated that most people are able to begin reading high-quality signs at approximately 900 feet away, or approximately 11 seconds of lead-time. This 11-second lead-time needs to be adjusted to account for an estimated 2-second deduction for the sharp angle and poor vantage point the driver experiences just before he/she is clearing the sign, as well as, an estimated 50% deduction for the simultaneous driving tasks the driver must also attend to (McNees & Messer, 1981). Thus, the 11-seconds of lead-time only allows approximately 4.5 seconds of actual reading time when speed is held constant. McNees and Messer (1981) assert that the acceptable minimum reading time for overhead guide signs should be at least 4 seconds, although the authors suggest that 6 seconds would be more desirable.

Exposure Time Considerations in the Current Study

The McNees and Messer (1981) formula for reading time estimates applies to research conditions involving dynamic driving situations or simulations. The present study assesses a diverse selection of sign types across different methodologies. Only the Driving Simulator method in the present study involved an increased cognitive load associated with driving tasks and dynamic stimuli. The video presentation method was dynamic but did not involve simultaneous driving tasks, and the remaining methods (i.e., PowerPoint slideshow presentation, Paper-and-pencil formats) did not involve dynamic stimuli or driving tasks. Accordingly, the stimuli exposure times needed to be adjusted in an attempt to make them relatively equivalent in terms of the participants’ available reading time.

The simulator method served as the benchmark for the other conditions in the present study. The signs in the virtual world were designed and pilot-tested to set the available reading time for the various signs at a range of approximately 4.5 to 6 seconds, varying slightly across the twelve signs. The Driving Simulator technology has resolution limitations that had to be considered in the estimates. The estimates included only the time beginning at the onset of legibility, as opposed to the initial appearance (to account for the resolution limitations of the

technology), and excluded the time when the signs began passing at a sharp angle out of the screen frame either above (as the vehicle passed under overhead signs) or in the periphery (as the vehicle passed by ground-mounted signs at roadside). The estimated available reading time of 4.5 to 6 seconds was not adjusted for the increased cognitive load of simultaneous driving tasks. The Driving Simulator pilot testing in the present study suggested that the 4.5 to 6 seconds of exposure time would provide sufficient variability across subjects.

The stimuli content for the Video presentation method was taken directly from an experimenter-driven run through the Driving Simulator. The videotape consisted of the virtual world stimuli content that appeared on the center screen in the Simulator condition. Due to the video's exclusion of the stimuli from the peripheral screens in the simulator, when the video of the stimuli was presented on the television monitor it reduced the comparative field of vision. This resulted in an available reading time for participants in the Video method of approximately 3 to 4 seconds. In light of the fact that the participants in the video condition did not have to contend with simultaneous driving tasks, and therefore had a relatively reduced cognitive load compared to the Simulator condition, the researchers believe that the downward adjustment in available reading time for the Video condition should help to offset the higher cognitive load present in the simulator condition. Although the viewing screen sizes that were used for the Video method varied, the visual angle was kept constant between trials. The visual angle (VA) can be determined using the following formula:

$$\tan(\text{VA}) = (\text{Height of the Screen}) / (\text{Viewing distance from the Screen})$$

This study adjusted the participants distance from the viewing screen to keep a consistent visual angle of approximately 8.7 degrees.

The PowerPoint slideshow method included the same 12 signs as the other methods in either isolation or road context taken from screen captures of the Simulator stimuli. The PowerPoint conditions do not require the simultaneous driving tasks of the simulator or the dynamic stimuli of the Video condition. Accordingly, the exposure time for static signs in the PowerPoint conditions was limited to 3 seconds per sign. Pilot testing indicated that the 3-second exposure time would help to offset the aforementioned differences present in the Simulator and Video conditions. Recall that Zwahlen and Schnell (2000) found a span of 75 meters between the first and last look distances, which at 60 mph allows approximately 3 seconds of exposure time. This estimate is further supported by McNees and Messer's (1981)

findings in a study of projected slides of multi-panel guide signs in which the median reading time was 2.9 seconds for the 50th-percentile of the sample.

In previous research studies, the Paper-and-Pencil method has been generally conducted without any time constraints. In the interest of equivalent comparisons to previous research, no exposure time constraints were imposed for the Paper-and-Pencil conditions in the present study.

Sign Stimuli Content and Context Background Research

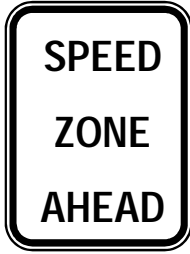
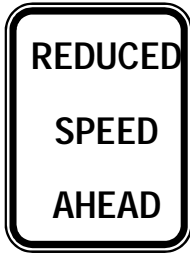
McNees and Messer (1981) conducted a study on guide sign comprehension utilizing projected slides of multi-panel guide signs with varied display times. In general, the authors found that the greater the information load (in terms of number of panels and bits of information per panel), the slower the participants' reading time. The authors also found that the briefer the display time, the faster the subjects responded. However, the rate of incorrect responses increased as the display time decreased. This suggests that participants adjust their response time in relation to the exposure time to the detriment of accuracy.

McNees and Messer's (1981) reading times included a one-second deduction for the estimated population average reaction/response time. The authors found that for the 6-second display times, the median (50-percentile) reading time averaged approximately 3 seconds for the 3-panel signs with 4 bits of information with a corresponding accuracy rate of 82% across the sample. For the 6-second display times with 4-panels and 4 bits of information, the median (50-percentile) reading time also averaged approximately 3 seconds but with a corresponding accuracy rate of only 63% across the sample. For the 4-second display times, the median (50-percentile) reading time was approximately 2 seconds for the 3-panel signs with 4 bits of information with a corresponding accuracy rate of 83% across the sample. For the 4-second display times with 4-panel signs with 4 bits of information, the median (50-percentile) reading time was slightly over 2 seconds but the corresponding accuracy rate decreased to only 69% across the sample. It should be noted the authors acknowledged practice effects associated with the same subjects responding to the same series of signs in the 4-second display condition following the 6-second display condition.

Sign Selection in the Present Study

For the present study, two 3-panel and two 4-panel guide signs were designed each averaging 4 bits of information per panel. The signs contained bits of information on upcoming exits, cities, streets, route numbers, and cardinal direction. The signs were purposefully designed to include only common words and language to avoid any complication of the participants' information processing which has been suggested to occur with uncommon or foreign words in sign comprehension (McNees & Messer, 1981; Smiley, Dewar, MacGregor, Kawaja, & Blamey, 1994). All city or street names were fictitious or non-local to avoid any familiarity biases. The present study elected to fix the display times for the PowerPoint method conditions at 3-seconds across the 3- and 4-panel signs with a consistent average of 4 bits of information.

The present study endeavored to select a diverse sampling of sign types to provide comparative findings to previous research in the area of sign comprehension. Several of the 12 signs and corresponding multiple-choice questions were taken directly from previous research. Figure 1 displays the questions that were taken from previous research, and the answer distributions for each sign.



What does this sign mean?

(Hawkins, Womack, Mounce, 1995) (est. n=1745)

1.9%	6.2%	The speed limit will be higher ahead.
3.7%	31.1%	The speed limit ahead will be strictly enforced by the police.
93.2%	55.0%	The speed limit will be lower ahead.
1.1%	7.7%	Not sure what it means



What is the most correct meaning of this sign?

(Picha, Hawkins, Womack, 1995)

(n=192)	(n=176)	
66.7%	71.6%	The lane ends and traffic in the right lane should move into the left lane.
10.4%	7.4%	The lane ends and traffic in the left lane should move into the right lane.
14.6%	5.7%	The median between opposing traffic will end.
4.7%	4.6%	There is a single lane ahead for both directions of traffic.
2.6%	9.7%	The lane you are in will become narrower.
1.0%	1.1%	I am not sure what this sign means.

Figure 1. Signs and Corresponding Questions Taken from Previous Studies.

METHOD

The present study consisted of sign comprehension method comparisons across six independent conditions involving four larger method categories: Driving Simulator, Video, PowerPoint Slide Show, and Pencil-and-Paper methods. The PowerPoint Slide Show and Pencil-and-Paper methods were each divided into two conditions that presented the sign stimuli either in isolation or within a roadway context. The sign stimuli were identical across all methods. Screen captures from the Driving Simulator animation were used to create the sign stimuli and road context stimuli for all other methods. The participants answered the same twelve questions in all conditions immediately following exposure to the respective sign stimuli with the exception of the Driving Simulator, wherein four of the twelve questions were measured via behavioral driving responses related to lane choice. The Appendix details the questions and corresponding sign stimuli for the questions used across the other methodologies.

The study included a total of 136 licensed drivers from a moderate-sized southwestern city. All participants were required to hold a valid driver's license. Recruitment flyers were posted on bulletin boards at a university. Supplemental recruiting was conducted via telephone calls to prospective participants from a lead pool of subjects who had participated in previous transportation studies or expressed interest in participating in transportation studies. Some participants were recruited on-site at local car wash and auto service retail outlets. Participants were paid an incentive for their participation.

The recruiting procedure involved a stratified sampling technique to ensure that the demographic characteristics of age and sex were balanced and representative. Each method included 24 participants, with the exception of the Driving Simulator method, which included 16 participants because of an unexpected attrition of older participants due to simulator-induced sickness. The conditions were all comprised of an equal number of males and females with an even distribution across two age brackets of 18 to 35, and 36 to 79. Each of the larger method categories will be described separately below.

Simulator Method

Participants. A total of 16 research subjects participated in the Driving Simulator portion of the study. The Simulator condition was originally intended to include 24 subjects. However,

due to repeated incidence of motion sickness among the older subjects and the high associated expense of this attrition, the experimenter elected to limit this method at 16 subjects. Subjects received an incentive of \$10 for their participation. In the event that a subject exhibited symptoms of motion sickness, the session was aborted and the subject was thanked, compensated, and dismissed, and subsequently replaced with another subject of consistent demographic characteristics.

Simulator Sickness. Table 1 shows the sickness rates by age and gender. These data show that nearly three quarters of the older participants who started the study had to stop due to sickness. Most of the participants who did ask to stop did so during the warm-up driving session which consisted of straight roads with no turns. Near the end of the warm-up course, a horizontal curve was included specifically to “test” for sickness. Because the test course included curves, the participants had the experience of driving a curve in the simulator during the warm-up. The majority of drop-outs did so within the first few minutes, prior to reaching the curve in the warm-up course. Most reported immediate vertigo, dizziness, and nausea. A few participants continued on to the experimental runs, but dropped out at various points in the experiments. All of these reported that they had initially felt a little queasy but had thought that they’d get use to it. One participant actually stopped and vomited during the study.

Subjects who felt sick were questioned concerning any medications they were taking, what type of spectacles (bifocals, trifocals) they were wearing, etc. No common thread that linked those that got sick was found.

Table 1. Simulator Sickness Rates

<u>Age</u>	<u>Male</u>	<u>Female</u>
18-35	0 / 4	0 / 4
35-54	0 / 4	1 / 4 (25%)
55+	4 / 6 (66.7%)	6 / 7 (85.7%)

Note: Number of Driving Participants who Stopped due to Sickness out of the Number who Attempted.

Apparatus. The Driving Simulator at the Texas Transportation Institute is produced by DriveSafety™ and runs through a 1995 Saturn SL mid-sized sedan with full instrumentation and provides a realistic interactive driving experience. The system includes a 150-degree wraparound visual field with high resolution (1024x768 pixels) projectors for each of the three integrated screens. Research participants control the accelerator and brake pedals and the steering wheel exactly how they do in an actual vehicle. For the present study, a custom driving environment was created using the HyperDrive™ Authoring Suite software. The driving simulator is illustrated in Figure 2.



Figure 2. TTI Driving Simulator

Measures. The Driving Simulator's integrated computer was programmed to calculate measures of vehicle velocity, acceleration, steering, braking, lane position, x and y coordinates, as well as time and location of the initiation of turn signals for indicating lane change information. Additionally, participants answered eight multiple-choice questions designed to assess their comprehension of eight corresponding stimulus signs they encountered during the driving experience.

Procedures. Participants participated in a practice session of approximately five minutes to familiarize themselves with the vehicle and the simulator driving experience before initiating the experimental session. This practice session also served to screen for motion sickness tendencies. The experimental session followed immediately after the practice session. Prior to engaging the vehicle, participants were provided a set of instructions and briefed verbally by the experimenter on the important details. Copies of the instructions, consent, and debriefing forms can be found in the Appendix of this report. Participants were instructed to drive in a normal fashion obeying all traffic laws, including speed limits, and respond accordingly to all relevant traffic signs and on-screen instructions. Participants were told to “drive to the city of Rico. Your starting point will be on Interstate 87 approximately 15 miles from Rico. You will need to pass through the city of Forest Hills to Interstate 27 to get to Rico. The road signs along the way should give you enough information to get there.” This destination task was presented to provide participants with a real-world driving task. It was meant to represent navigating in an unfamiliar area by following guide signs to a destination city. Participants were advised that at various spots along the way, text messages would appear at the top of the screen instructing them to briefly pull over to the side of the road to answer the corresponding question(s) about the signs they encounter. A clipboard containing the multiple-choice questions was provided to participants prior to starting the experimental session. All multiple choice questions were answered on paper with the participant circling their choice.

Due to the resolution limitations of the projection equipment, participants were forewarned that distant signs would appear to ‘flicker’; however, at appropriate speed limits the signs would become legible as they approached them. Participants were instructed to generally stay in the right-most lane with the stipulation that occasionally they may need to change lanes due to changes in the number of lanes on the freeway, road construction, accident scenes, and to take or avoid exits at freeway interchanges. Participants were instructed that when they felt it was necessary and appropriate to change lanes to remember to use their turn indicator. Participants were instructed to assume that there are no other cars in their blind spot because no rear or side view mirrors were made available in the simulation. Each session took approximately 40 minutes to complete the driving course.

Video

Participants. The Video method included 24 participants with an equal number of males and females with an even distribution across two age brackets of 18 to 35, and 36 to 79. Participants were tested individually or in groups of up to eight people. Each participant was compensated \$ 10.00.

Apparatus. The video stimuli footage was derived directly from the Driving Simulator's center screen. The participants viewed a videotape of a complete run through the same experimental world as used in the actual Driving Simulator condition. An experimenter drove the route to create the tape to ensure that vehicle speed and direction were controlled. The experimenter followed the same directions given for the simulator method, and also obeyed all signs, traffic rules, and speed limits. Just as in the simulator method, the driver pulled over after each stimulus to allow time for the participants to answer the multiple choice questions. The television was placed to produce a visual angle of 8 – 9 degrees for the seated subjects.

Measures. Participants answered multiple-choice questions designed to assess their comprehension of twelve corresponding stimulus signs they encountered along the roadway presented in the video.

Procedures. Prior to beginning the session, participants were required to read and sign a consent form, and were provided with a brief set of written instructions followed by a brief verbal review of the instructions by the facilitator. Important verbal instructions included: "Please do not turn the page until instructed to do so, Please do not look at your neighbor's sheet, Your Destination is Rico, and if you are unable to read a sign, choose *Cannot read the sign* as your answer to the multiple choice question and do not guess the correct answer". Once the participants were ready, the instructor started the video. The video contained built-in pauses after each sign stimulus that allowed the participants to answer the appropriate question. The VHS video was shown on a 19-inch color television at a distance of eight feet from the viewer. Care was taken to insure that each viewer had a clear line of sight to the television screen. Some testing took place in TTI offices, and other sessions were held at off-campus locations including other office buildings and private homes. A video session is illustrated in Figure 3.



Figure 3. Group testing using video method

PowerPoint Method- Road Context and Isolated Sign Conditions

Participants. A total of 24 subjects was used for each of the PowerPoint conditions, split equally between male and female and the 18 to 35 and 36 and up age brackets. Each participant was compensated \$10.00.

Apparatus. PowerPoint was the software used to create timed slide shows of the sign stimuli in-context on the roadway for the first condition, and of the isolated signs for the second condition. The in-context displays were created by taking screen dumps from the driving simulator software. The isolated signs were simple black-and-white line drawings of each sign sized to completely fill the computer screen. The PowerPoint presentations used animation programming to limit the viewing time of the screen prints to 3 seconds each. Because of the flexibility of PowerPoint, test runs were performed in two manners. The first was in a classroom setting, using a laptop computer and projector to display the images on a large screen for several people at once. The second set up involved one subject viewing a laptop screen at a time. For the first condition, the slides were of the sign stimuli in position along the driving scenario

roadway. The presentation for the second condition was altered to only contain slides of black and white line drawings of the signs on a white background.. The presentations required a manual cue from either the facilitator or the participant to continue with the next slide.

Measures. To assess their comprehension of the chosen signs, the participants answered the same 12 multiple choice questions that were given for the Video method and would also be given in the remaining methods. The questions were contained in a packet with one question to a page. An example question from each of the condition's packet can be found in the appendix.

Procedures. Prior to beginning the session, participants were required to read and sign a consent form, and were provided with a brief set of written instructions followed by a brief verbal review of the instructions by the facilitator. Important verbal instructions included: Please do not turn the page until instructed to do so, Please do not look at your neighbor's sheet, Your Destination is Rico, and if you are unable to read a sign, choose "Cannot read the sign" as your answer to the multiple choice question and do not guess the correct answer. The participants were also reminded that the slides would only be viewable for 3 seconds and that it was important for them to be focused on the projector screen or laptop to be exposed to the complete viewing time.

When the subject or subjects were ready, the experimenter began the PowerPoint presentation. After three seconds of viewing time, the program instructed the participants to answer the appropriate question, and then displayed "Press the Red button to Continue". Then the participants flip the page to the appropriate question and mark their answer. Once this was done, depending on if there were multiple participants or just one, the experimenter or the single participant pressed the space bar (the red button) on the laptop to continue to the next slide. This process was continued for all 12 slides.

When completed, the participants filled out a questionnaire containing demographic and driving information about themselves and were compensated for their time. Both the Road Context and Isolated Signs conditions of the PowerPoint method followed the same procedures.

Pencil-and-Paper Method- Road Context and Isolated Signs

Participants. A total of 24 subjects were used for the both the Road Context and Isolated Sign conditions for the Pencil-and-Paper Method portion of the study, split equally between male

and female and the 18 to 35 and 36 and up age brackets. The subjects were compensated \$5 for their time.

Apparatus. The only apparatus involved in this method were the packets containing the multiple choice questions. The difference between these question packets and the previous ones, was that they contained either the Road Context of Isolated Sign picture above the corresponding question, depending on which conditions was being tested. These pictures were identical to the slides shown in the two PowerPoint conditions.

Measures. The measures for this method only include the question packets. An example question from each of the condition packets can be found in the appendix.

Procedures. Before completing the multiple choice question packet, participants were required to read and sign a consent form. The participants were allowed to work at their own pace, taking as much time as they needed to look at the sign pictures and answer the question. When finished, the participants filled out a questionnaire containing demographic and driving information about themselves and were compensated for their time.

RESULTS

The data were analyzed with Statistical Package for Social Sciences (SPSS) software. Analyses included General Linear Model *a priori* mean difference comparisons for all items by method. Items were recoded into dichotomous Right or Wrong responses for these analyses.

The overall omnibus ANOVA across all methods for the average correct responses to all items was significant ($F(5, 130) = 15.63, p < 0.001$). This was expected given the broad spectrum of methodologies tested and the researchers place more emphasis on the planned comparisons between the individual methods. The methods utilized in this study fall along a continuum with respect to how authentically they create a realistic driving experience. The continuum spans from highly realistic (Driving Simulator) to highly contrived (Paper-and-Pencil isolated signs condition). Figure 3 depicts the percentage of total correct responses across items for each method. The video-based presentation method fared the worst with an average of 59% correct responses across individual items. The PowerPoint slideshow method had an average of 64% correct for the road context condition and an average of 63% correct for the isolated sign condition. The Video and PowerPoint methods were not statistically different in total correct responses across items ($p < 0.17$). The Driving Simulator method received an average of 70% correct responses, which was significantly higher than the Video method ($p = 0.006$), but only marginally higher and not significant compared to the PowerPoint methods ($p < 0.10$). The Pencil-and-Paper conditions generated the highest correct responses across all items with the isolated sign condition and the road context condition both receiving an average of 82% correct responses across items. The Paper-based conditions received significantly higher average correct response rates than all of the other methods ($p < 0.004$). The isolated sign stimuli and road context stimuli conditions were not significantly different for Pencil-and-Paper method across all items ($p = 0.92$).

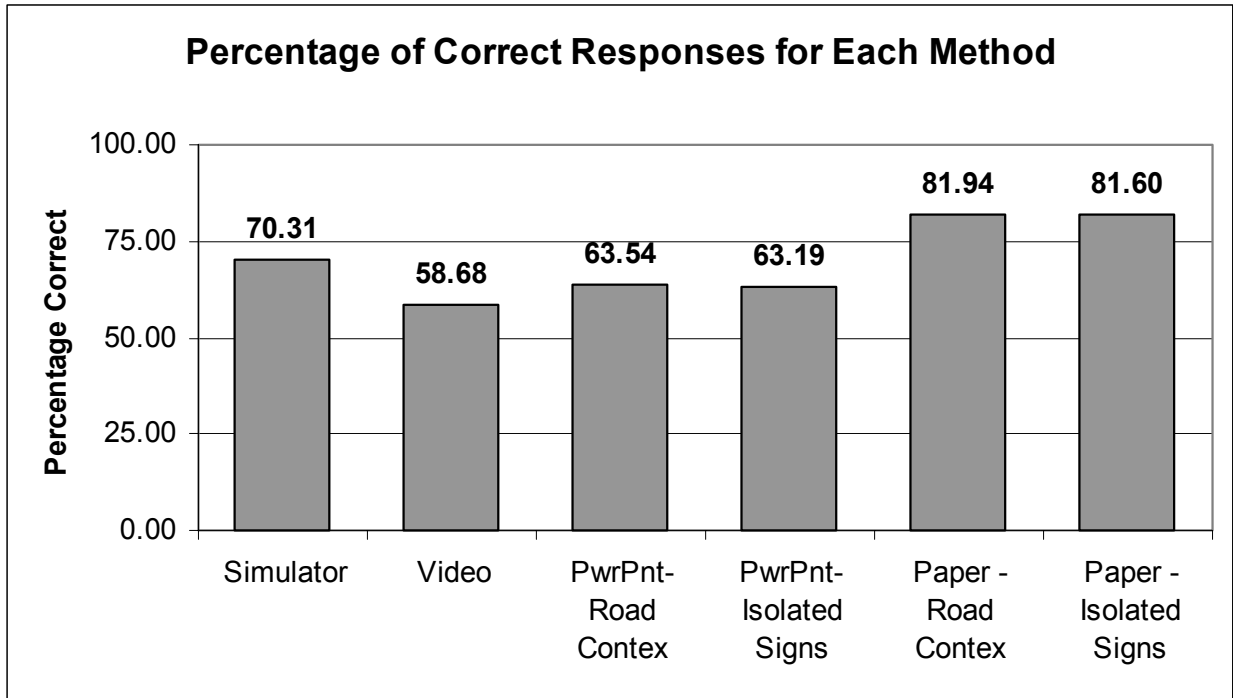


Figure 4. Percentage of Correct Responses for Each Method.

Sign and Question numbers correspond without deviation across methods throughout the study. Several significant Differences were found between methods for individual items/signs. Questions Q1, Q2, Q5, Q6, Q9, Q10, and Q11 had significant F statistics for the overall method omnibus test. Given the dramatic methodological differences between the six conditions coupled with the diverse variety of individual signs, the omnibus test's statistical significance for individual questions is not surprising. The specific question comparisons across methods detailed below are more informative. Figures 3 - 14 provide charts across methods for each individual question, as well as illustrate the individual sign stimulus.

12 Stimuli

Lane Ends Merge Left. The Video and PowerPoint scores appear to suffer from time constraints. The Video method produced significantly lower scores than both paper methods ($p < 0.01$). There was a significant difference between PowerPoint condition with road context stimuli and Paper isolated signs methods ($p = 0.04$). Additionally, the PowerPoint isolated signs condition was significantly different from both Paper methods ($p = 0.04$). No significant differences were found between pairings of similar methods (i.e., Simulator and Video, PowerPoint road context and PowerPoint isolated signs & Paper road context and Paper isolated signs). No significant difference was found between Simulator and any of the other methods. (See Figure 4)

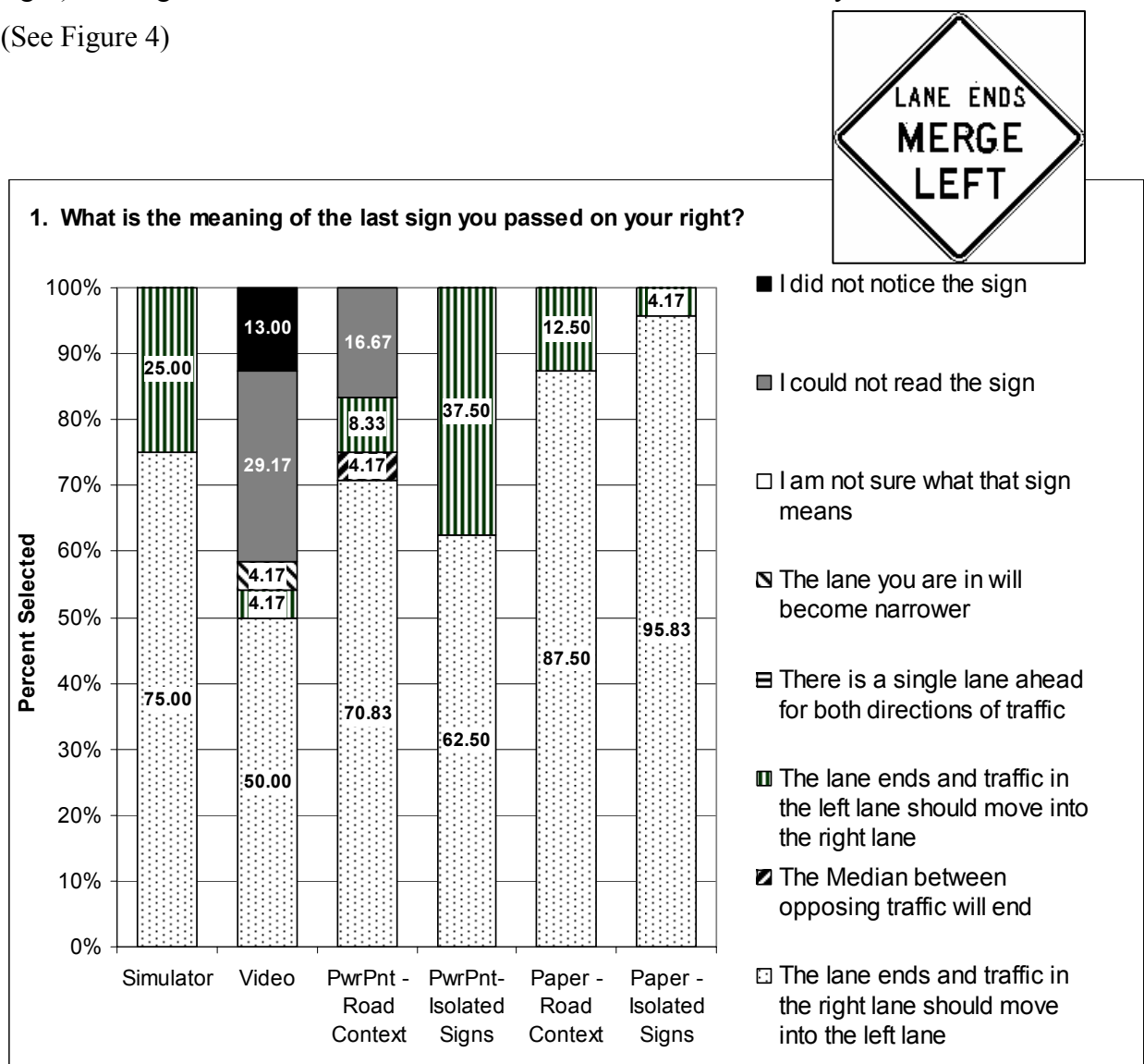


Figure 5. Lane Ends Merge Left.

No Left Turn symbol. The Simulator and Video methods both had significantly lower scores than all other methods ($p < 0.001$). Moreover, the Simulator method scores were significantly lower than Video scores ($p = 0.04$). In both conditions, the sign appeared on the left side of the road. Therefore, the unexpected location of the stimulus sign may have influenced scores more in these dynamic motion methods (See Figure 6).

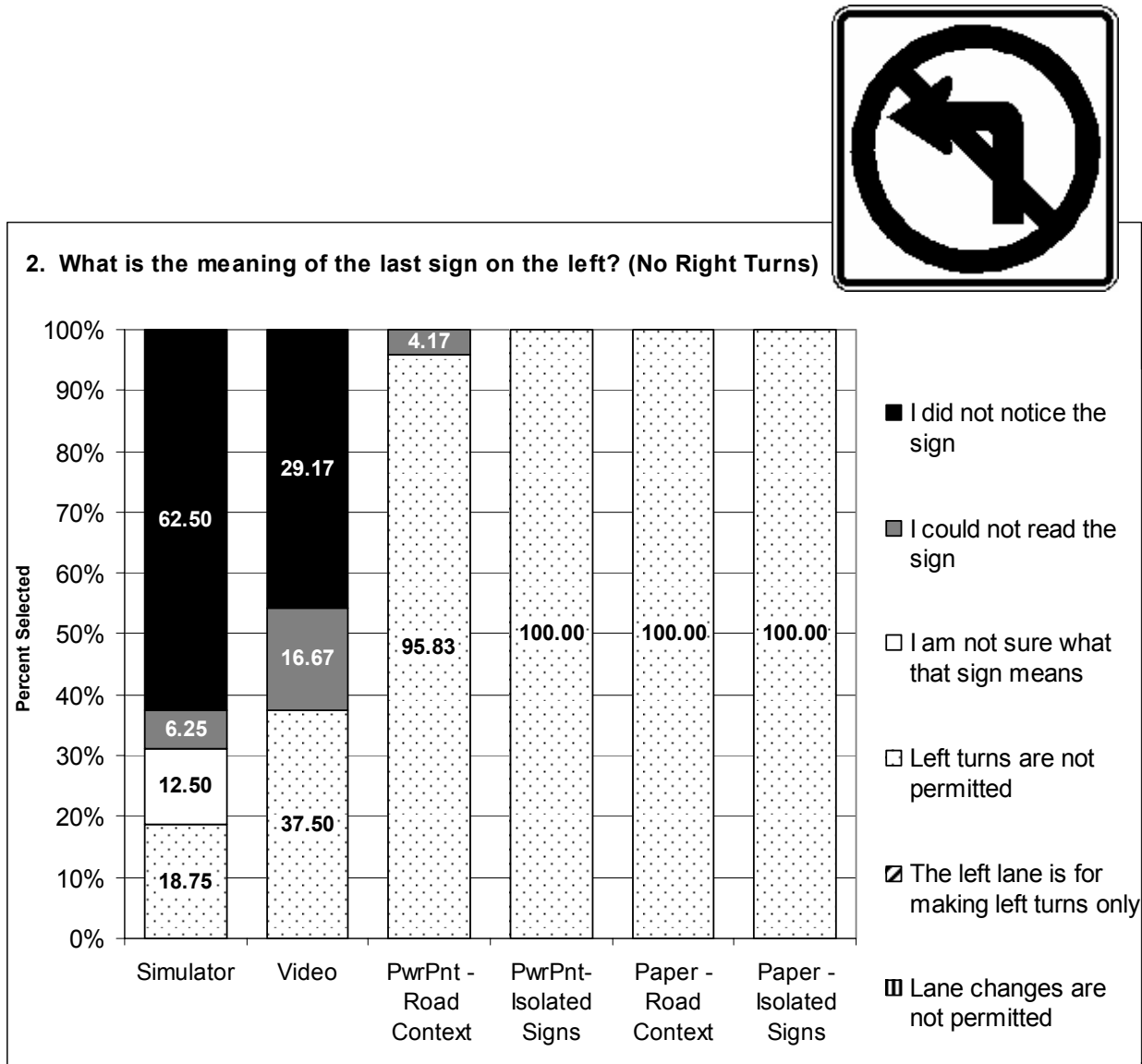


Figure 6. No Left Turn Symbol

Speed Zone Ahead. No significant differences were found between any of the methods. This is possibly an artifact of the relatively low correct response rates across all methods ($M = 63\%$ correct). The Simulator method had the highest correct response rate at 81%, which appears to have been influenced by a visible yellow warning sign indicating a curve in the road off in the distance. The distant warning sign was not as salient or even discernible in the other methods that provided context because of the reduced screen or image size. (See Figure 7)

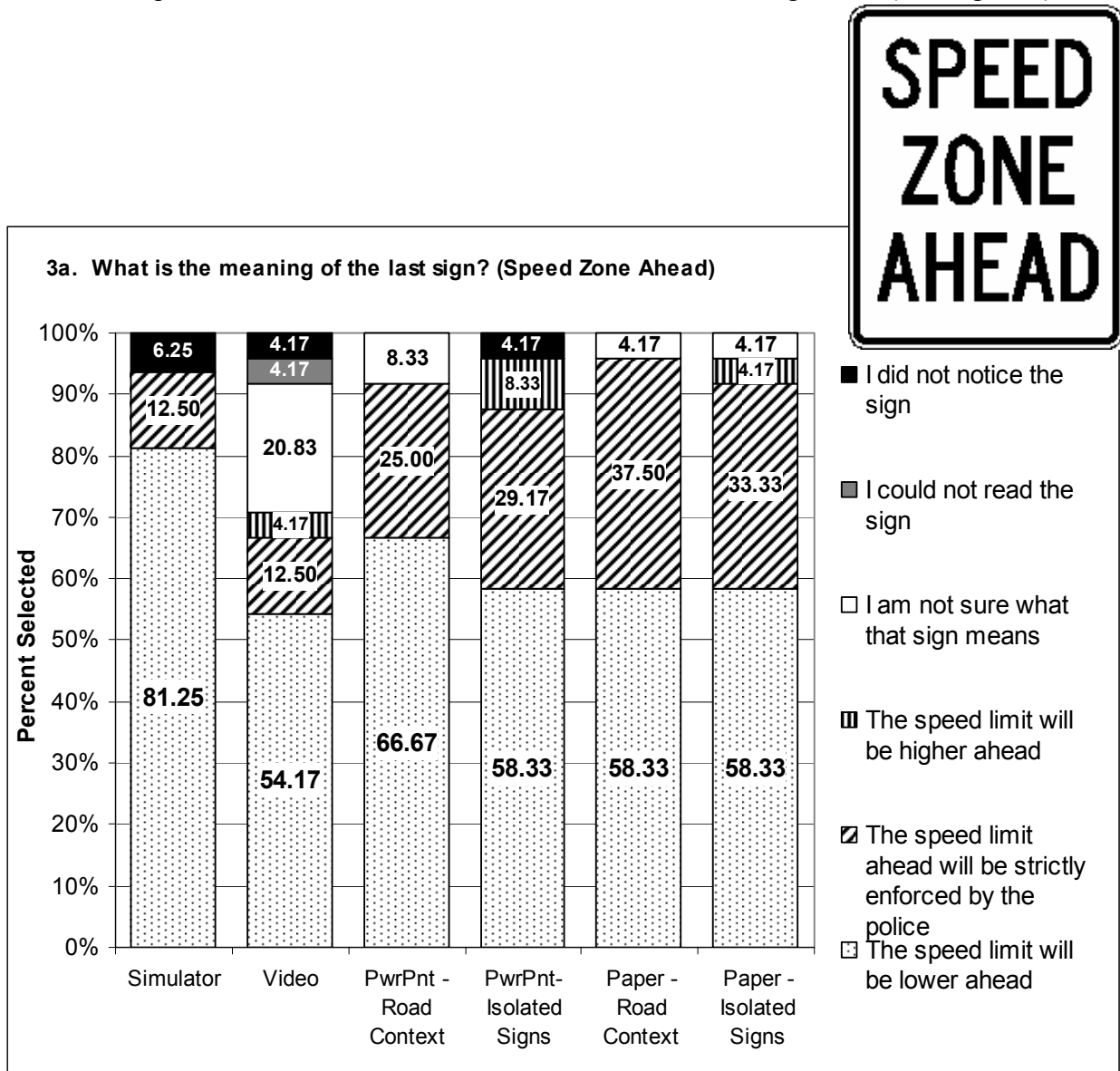


Figure 7. Speed Zone Ahead.

HOV Lane Ahead. The Paper-based methods produced significantly higher scores than both Simulator and PowerPoint road context methods ($p < 0.05$). No significant differences were found between other methods (See Figure 8).

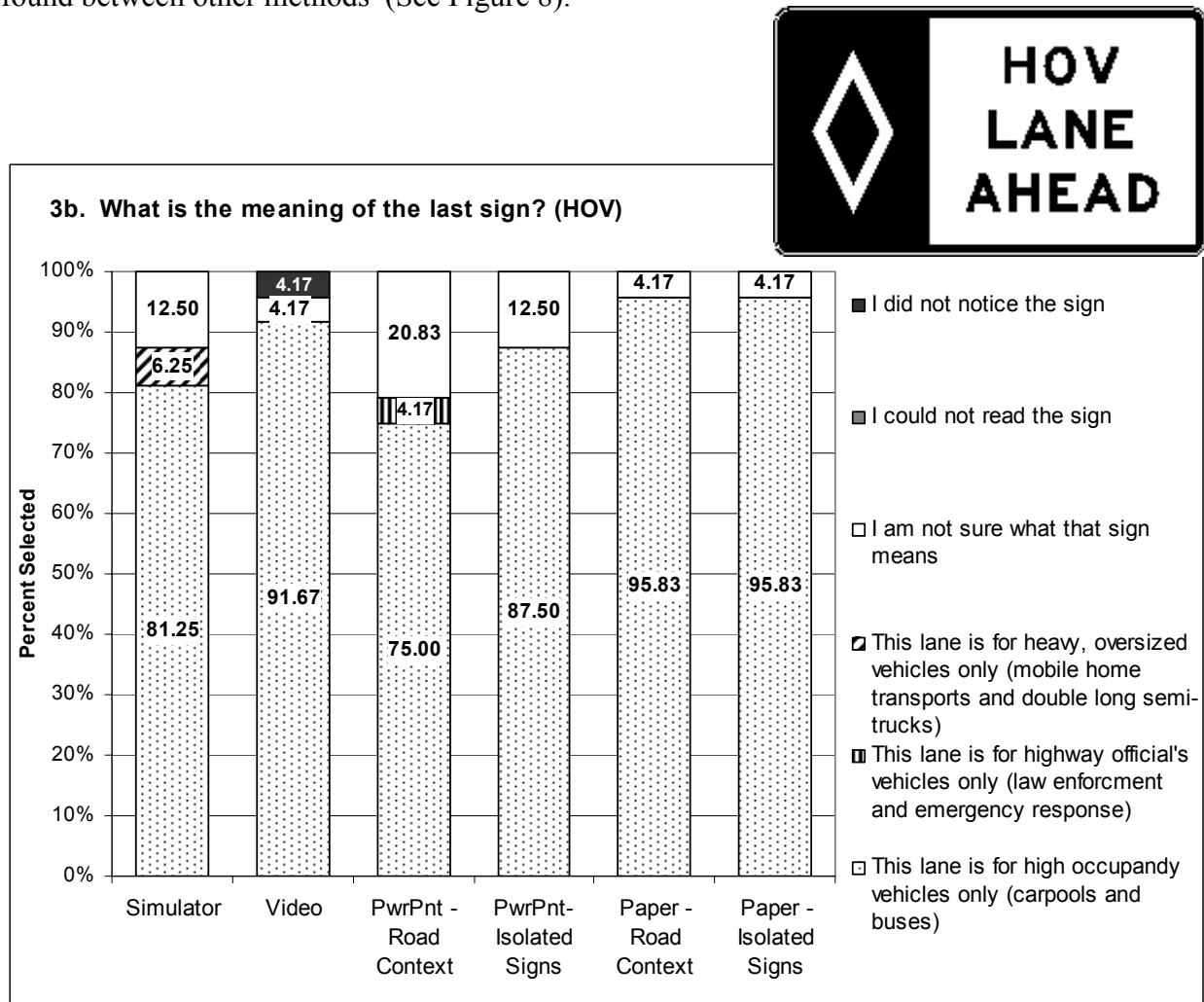


Figure 8. HOV Lane Ahead

Merge Left symbol. No significant differences were found between any of the methods (See Figure 9).

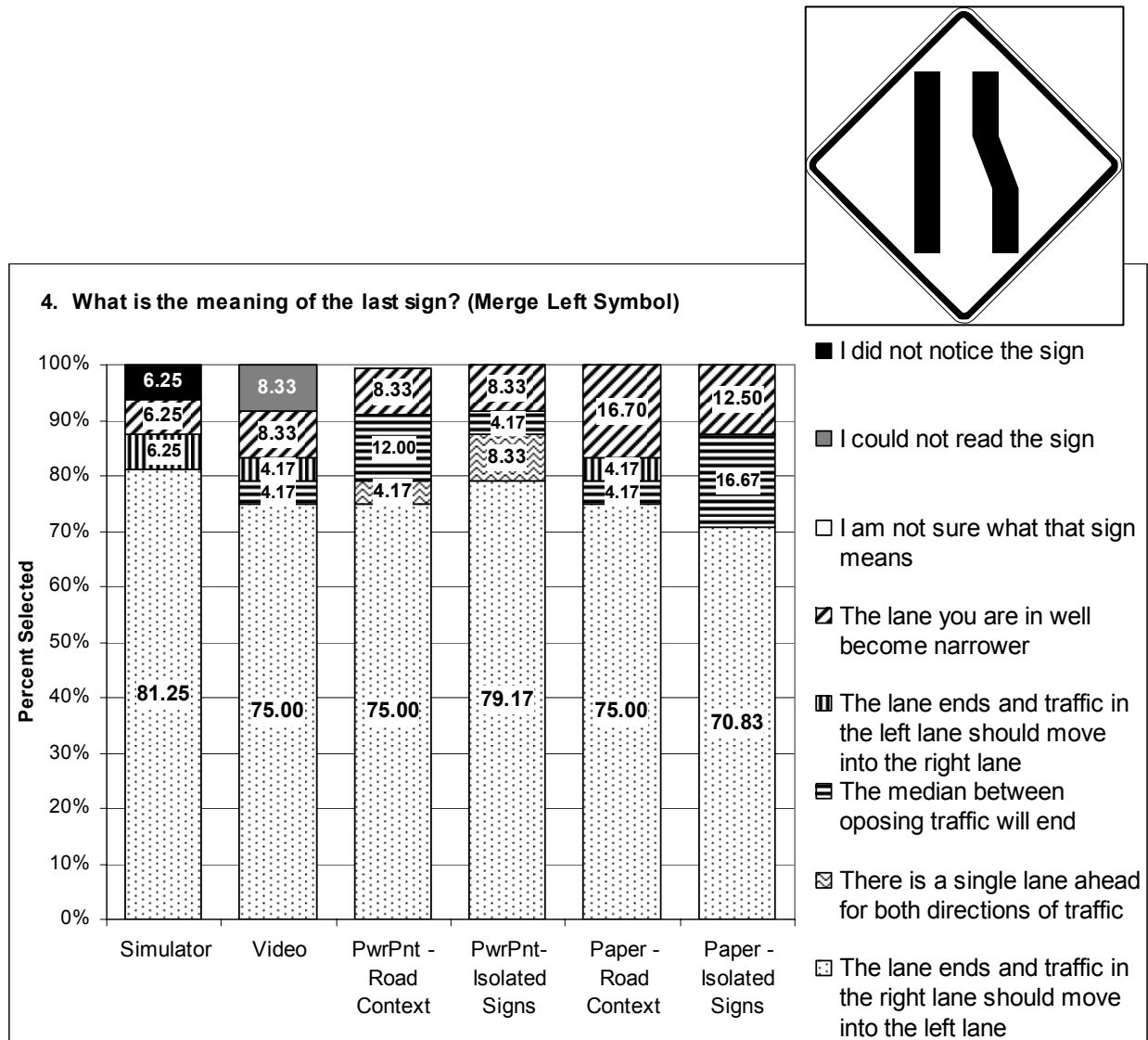


Figure 9. Merge Left Symbol.

Three Panel Interstate Guide Sign. Paper methods were found to be significantly different from all other methods ($p < 0.001$). The Paper methods did not differ significantly from each other ($p = 1.00$). The perfect correct response rate for the Paper conditions are in sharp contrast to the low correct responses in the other methods, which range from 17% correct

(PowerPoint isolated signs) to 6% (Driving Simulator). Scores were clearly influenced by the attention and recall required for all methods except the Paper methods (See Figure 10).

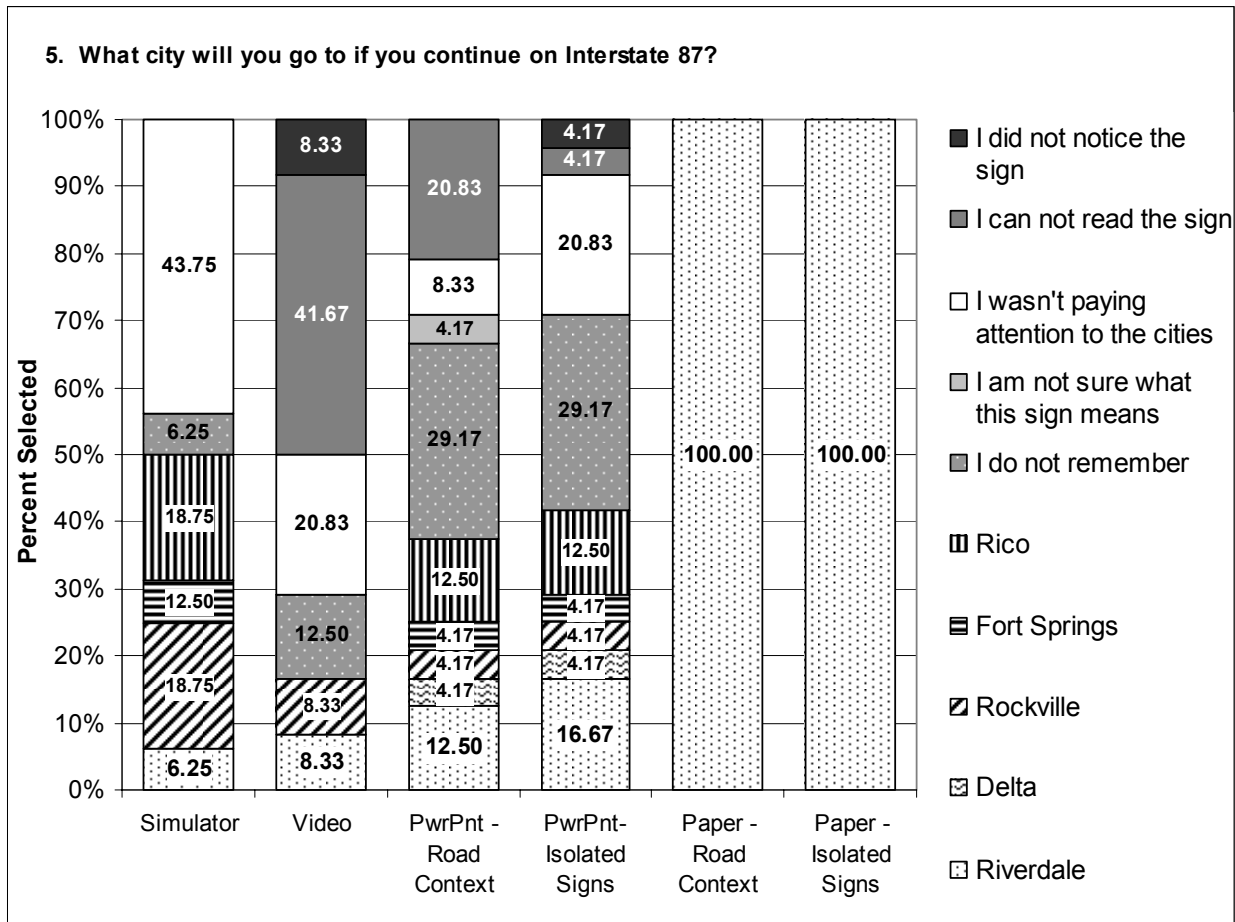


Figure 10. Three Panel Interstate Guide Sign

Four Panel Interstate Guide Sign. The sign stimulus was a four-panel guide sign. The scores for this lane choice item cluster in two method groups. The high scores were the Simulator and Paper methods. The low scores were Video and PowerPoint methods. Significant differences were found between groupings ($p < 0.003$), but no significant differences were found within groupings ($p < 0.53$). The method clusters suggest that the differences might be an

artifact of the stringent time constraints associated with the Video and PowerPoint methods. The four-panel stimulus might have caused an information processing overload under the strict time constraints (See Figure 11).

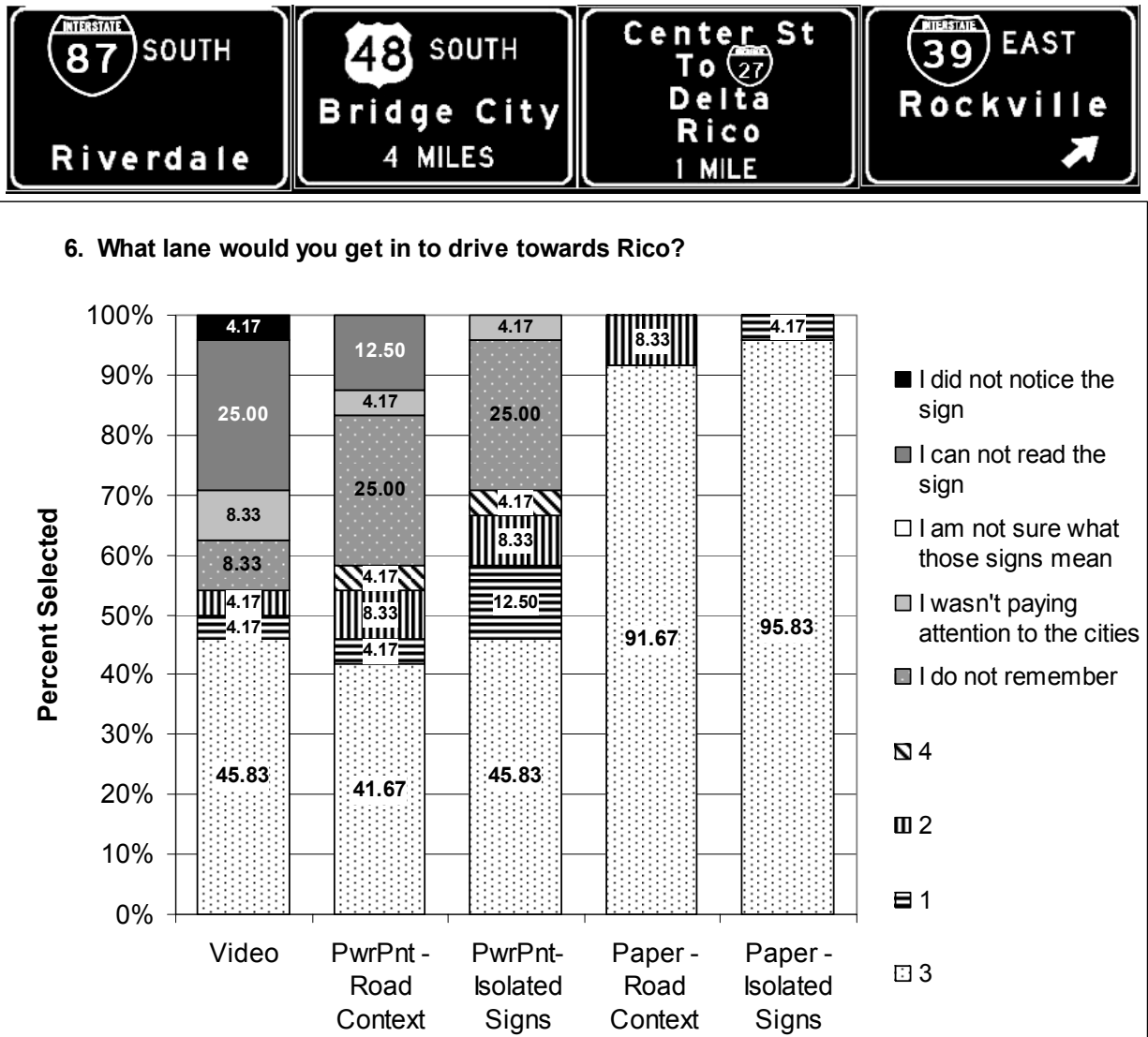


Figure 11. Four Panel Interstate Guide Sign

Center Lane Only. Only the Simulator method (highest score, 81% correct) and the Video method (lowest score, 46%) differed significantly ($p = 0.03$) (See Figure 12).

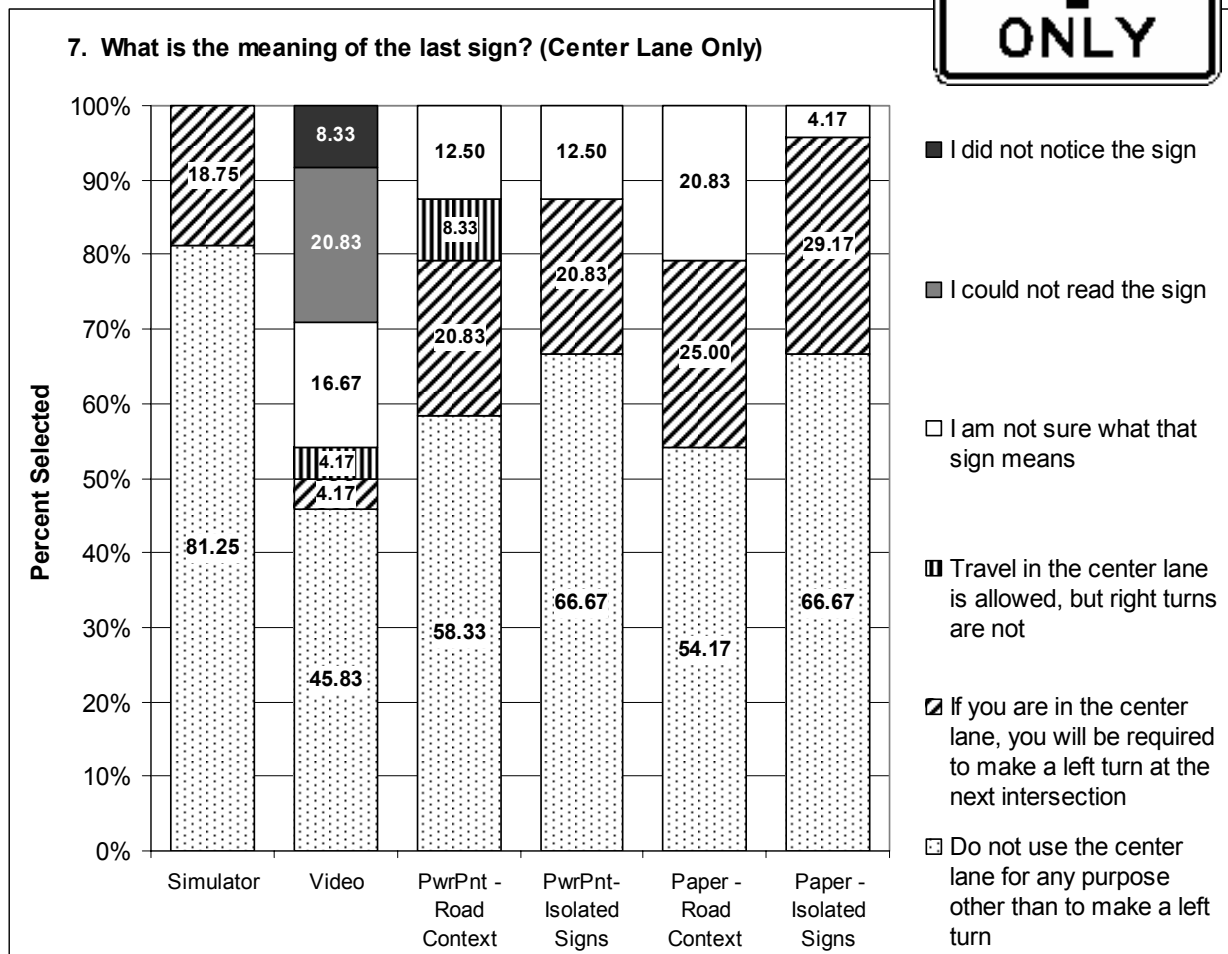


Figure 12. Center Lane Only

Single Panel Interstate Guide Sign. The sign indicated a fork that required participants to choose the left lane. The Video method generated highest score (100% correct). The Video

method had significantly higher score than PowerPoint isolated sign condition (75% correct) and Simulator (75% correct) methods ($p < 0.05$) (See Figure 13).

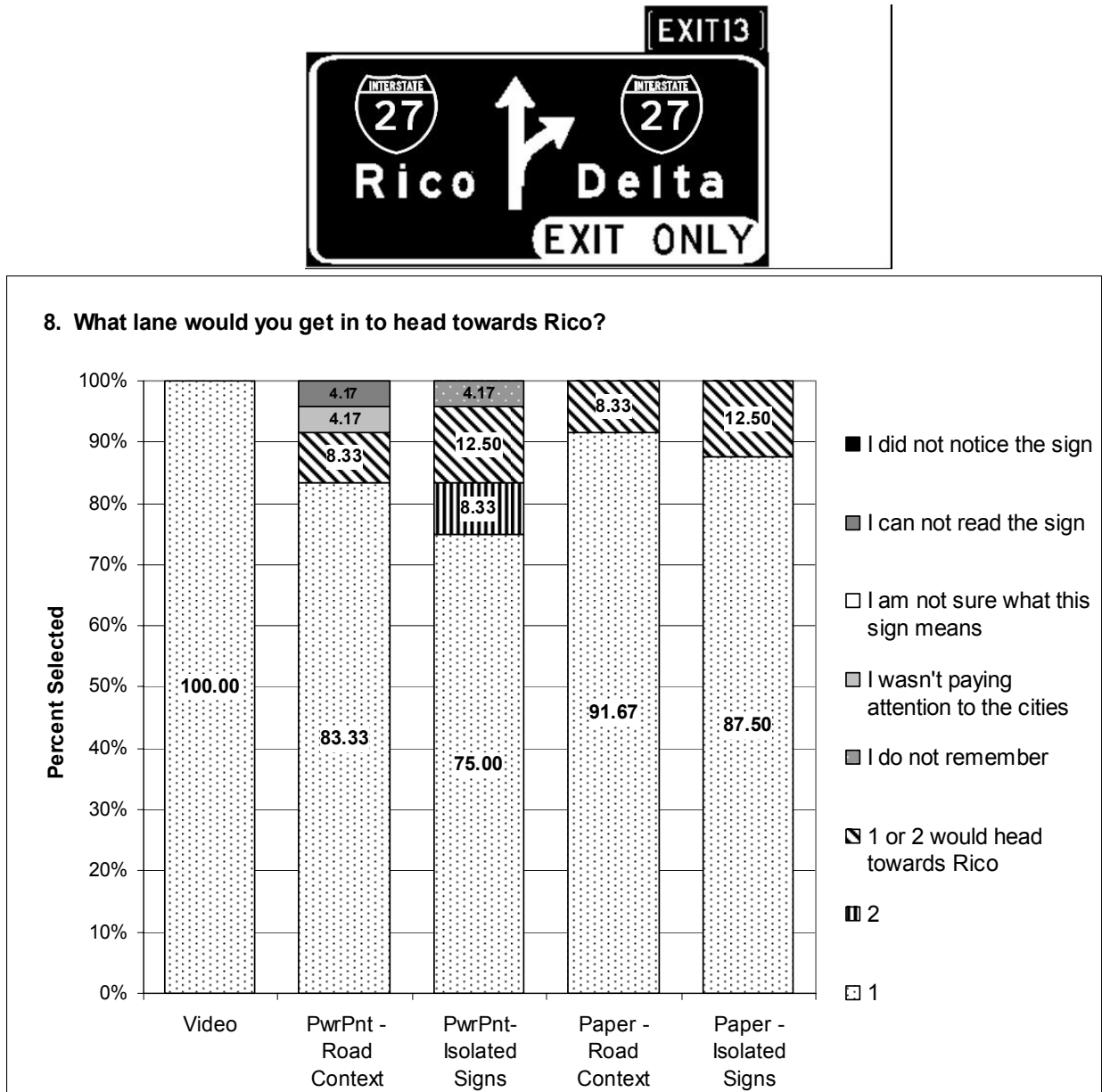


Figure 13. Single Panel Interstate Guide Sign.

Reduced Speed Ahead. The Video method (88% correct) was significantly lower ($p < 0.01$) than all other methods (all other methods 100% correct). Given the consistent high score across all other methods, the data suggest that the combined effects of motion, limited time

exposure, and resolution clarity probably influenced comprehension of an explicit and otherwise simplistic warning sign in the Video condition (See Figure 14).

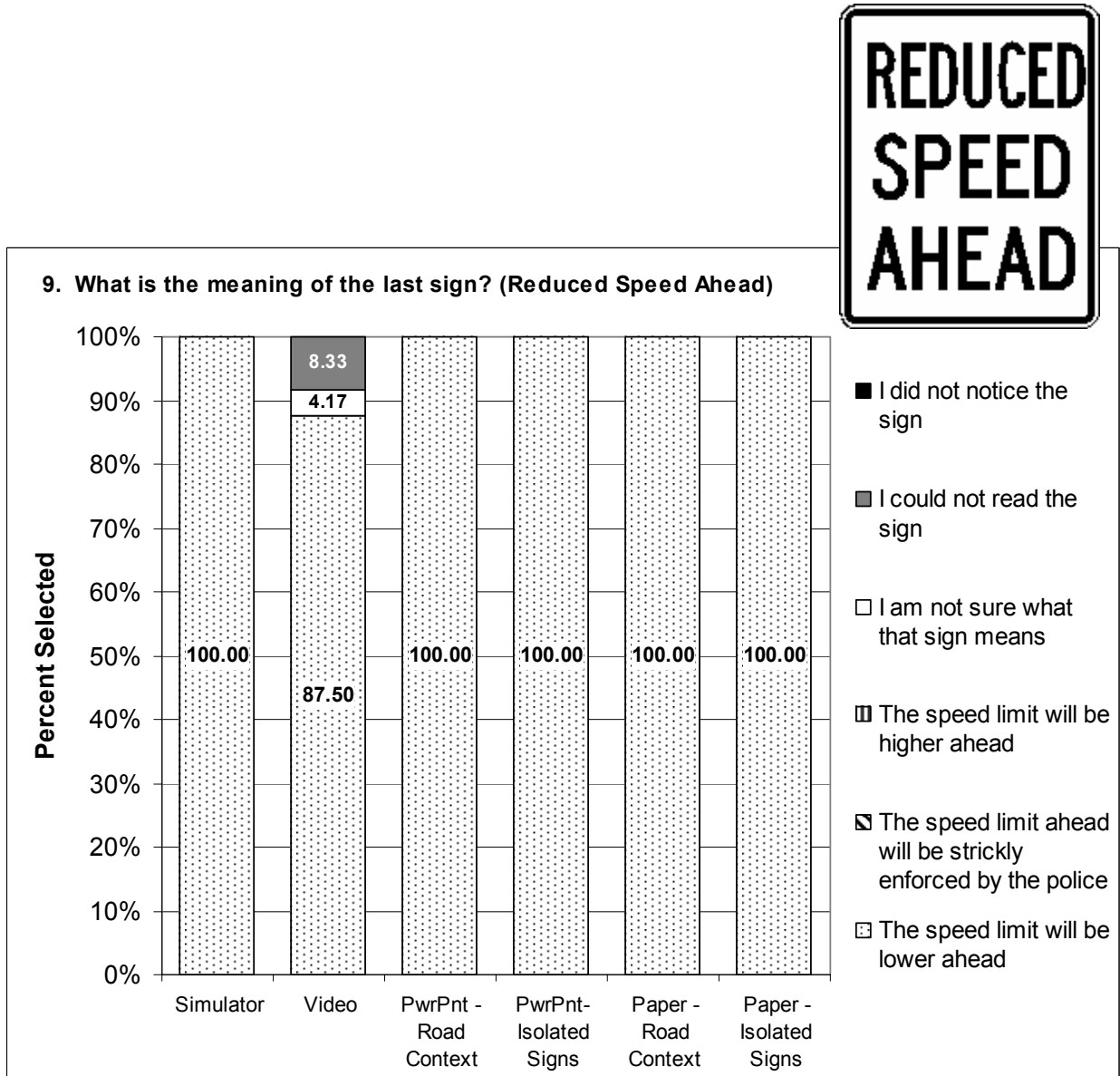


Figure 14. Reduced Speed Ahead.

Three Panel Interstate Guide Sign. Simulator method produced significantly higher scores than all other methods except for the Paper road context condition ($p < 0.001$). The Paper road context condition produced significantly higher scores than all other methods ($p = 0.02$) except the Simulator. There was no significant difference between Simulator and Paper road

context condition methods. The average correct response rate across all methods was only 20% (See Figure 15).

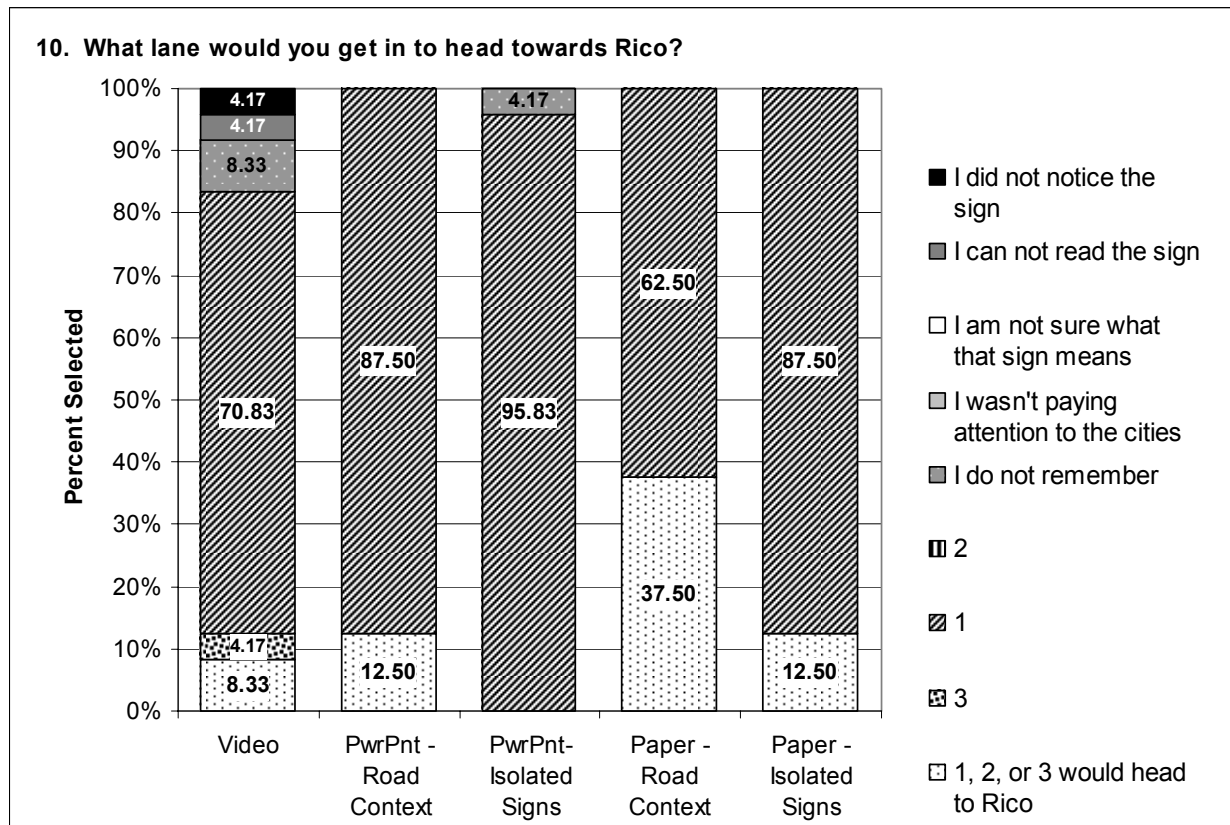


Figure 15. Three Panel Interstate Guide Sign.

Four Panel Interstate Guide Sign. The PowerPoint methods produced significantly lower scores than all other methods ($p < 0.01$). There were no significant differences between the scores for any of the other methods. Moreover, no significant difference was found between the two PowerPoint methods. The lower scores in the PowerPoint methods may be a function of the strict 3-second exposure limit in those conditions (See Figure 16).

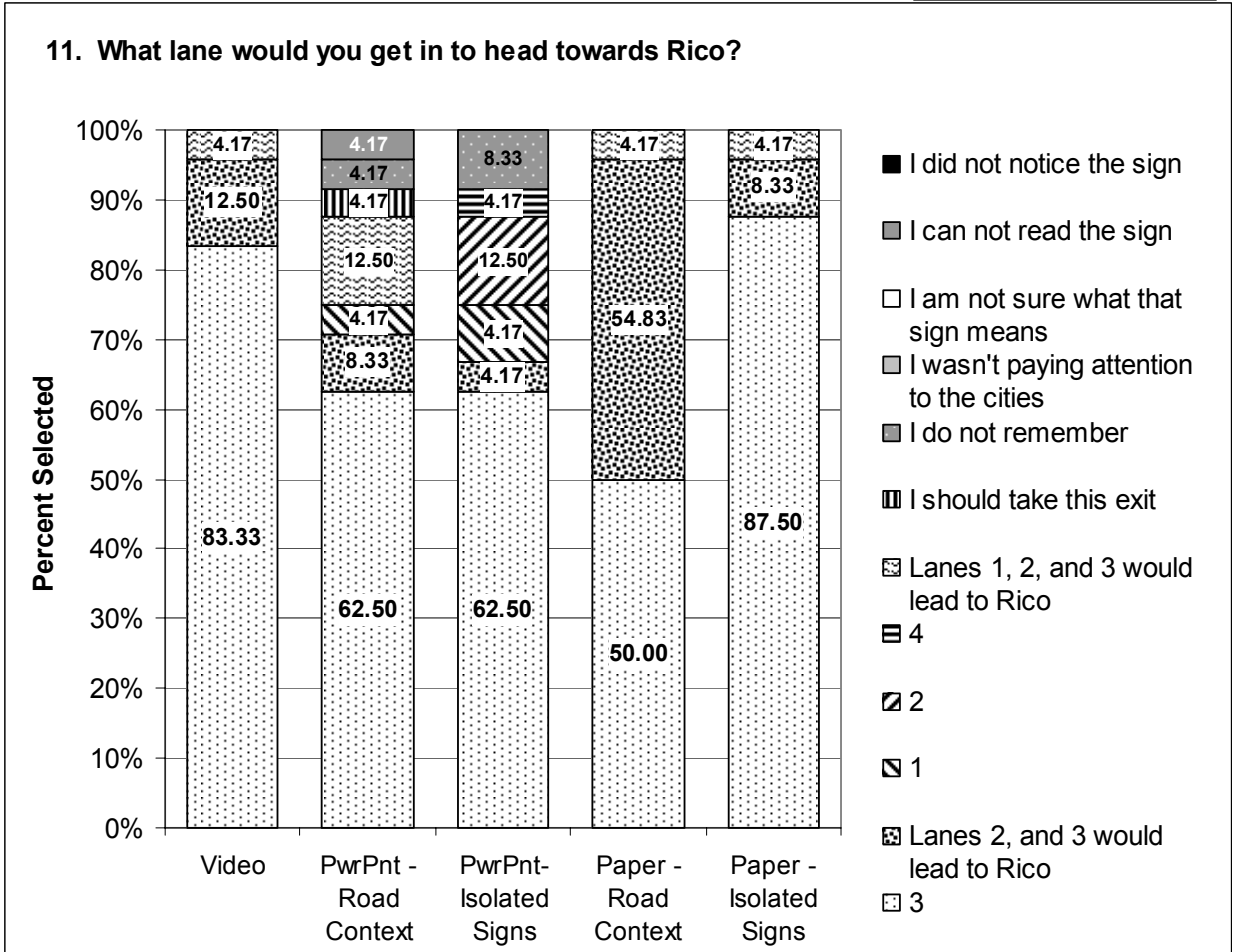
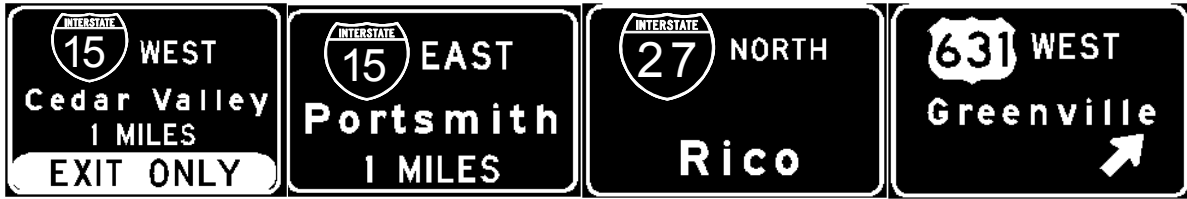


Figure 16. Four Panel Interstate Guide Sign.

Moderator Variables

Static vs. Dynamic Methods. Static methods (Paper Road Context, Paper Isolated Signs, PowerPoint Road Context, PowerPoint Isolated Signs) produced significantly higher scores (73% correct) than dynamic methods (Simulator, Video) (64% correct) across all sign types ($p = 0.001$). This suggests that either the resolution of the methods was significantly worse, or that the added element of realistic motion adversely affects the accuracy of sign comprehension. Due to the fact that drivers must process and comprehend signs under dynamic motion conditions,

static research methods may be producing deceptively elevated comprehension rates that will not replicate in actual driving situations.

Isolated Sign Stimuli vs. Signs Displayed in Road Context. No significant differences were found for the analyses of the road context variable across all signs within media method. This suggests that for the Paper-and-Pencil or PowerPoint presentation methods the road context might not provide much of an advantage to the research participant over and above the sign stimuli. The results are listed below:

Paper Road Context = 82% correct

Paper Isolated Signs = 82% correct

PowerPoint Road Context = 64% correct

PowerPoint Isolated Signs = 63% correct

No Limit in Exposure Time vs. Exposure Time Limit. The methods with No Exposure Time Limit (Paper-and-Pencil based methods) produced significantly higher scores (82% correct) than the methods in which Exposure time was strictly limited (PowerPoint Road Context, PowerPoint Isolated Signs, Simulator, Video) (64% correct) across all sign types ($p < 0.001$). As expected, exposure time is an important moderating variable and had one of the most dramatic effects in the present study.

Graduated Differences in Time Constraints. The Paper-based methods had no exposure time limitations and produced significantly higher scores (82% correct) than each of the other time-constrained methods ($p < 0.001$). The Simulator method had exposure times ranging from four to six seconds (varying based on sign size and resolution clarity, and driver-controlled speed) and produced significantly higher scores (70% correct) than the video method (59% correct) ($p = 0.006$). The Simulator method scores did not differ significantly from those of the PowerPoint method (63% correct). There was no significant difference between the Video and PowerPoint methods when investigated across all sign types ($p = 0.13$). The estimates for exposure time of the different methods are as follows:

Paper Road Context, Paper Isolated Signs = Unlimited

Simulator = 4 to 6 seconds (speed influenced)

Video = 3 to 4 seconds (fixed speed, but limited by monitor frame)

PowerPoint Road Context, PowerPoint Isolated Signs = 3 seconds

CONCLUSIONS

The results are encouraging for the use of less expensive and portable methods to test traffic sign comprehension. The Powerpoint presentation with limited exposure time produced comprehension scores similar to those obtained by participants in the driving simulator. The investigators had expected that the Video presentation, because of the dynamic nature, would be most similar to the simulator. Because the resolution of the video was poor, the text signs fared poorly in the Video presentation. The data suggest that simply limiting the exposure time, as was done in the time-limited Powerpoint presentation, produced enough cognitive load to mimic simulator performance.

The data also indicate that previous studies which used unlimited exposure time may have overestimated comprehension when compared to the time-limited exposure and the dynamic conditions. The time-limited exposure more closely matches actual driving conditions and should provide more reliable estimates of comprehension.

Future studies of sign comprehension would benefit in several ways by using the limited-exposure method. First, the portability of the experimental apparatus has great benefits. A laptop computer is all that is necessary. Studies could be conducted in targeted geographical areas and with participants who may not be willing or able to come to the University where the driving simulator is housed. Second, the amount of effort and expertise required to prepare stimuli for these studies is much less than for simulator studies. Using actual photos, or those altered in image-editing software such as PhotoShop or Corel Draw, and placing them into a Powerpoint presentation is a relatively straightforward procedure. Some pilot testing is necessary to establish the presentation duration appropriate for the stimulus complexity. Third, multiple subjects could be run simultaneously either in a classroom setting with a projected image or with multiple computer stations running independently.

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APPENDIX

Consent Forms

Note: Consent forms for the other 5 methods were similar but did not require as much explanation as did the one for the simulator. The other 5 forms can be obtained by contacting the first other.

INFORMED CONSENT: Page 1 of 2

I have been invited to participate in an experiment to evaluate traffic sign comprehension as presented in a driving simulator. The experiment is to take place in the Gibb Gilchrist Building. I am being selected as a possible participant because I have normal or corrected to normal vision, I am between the ages of 18 and 73, I possess a valid driver's license, and I have no apparent limitations impeding my ability to drive. I have been instructed to read this form and ask any questions I may have before agreeing to participate in the study. This experiment is being conducted by Susan T. Chrysler of the Texas Transportation Institute (TTI), part of the Texas A&M University System. The Southwest Region University Transportation Center is funding this experiment.

Background Information: The purpose of this study is to evaluate traffic sign comprehension as presented in a driving simulator.

Procedures: If I agree to be in this study, I am asked to participate in a brief instructional session, a practice session, and the experimental sessions in the simulator. I will also be asked to complete a brief questionnaire. This study will take no longer than 75 minutes.

Introductory Session: During the introductory session I will read this consent form. I will indicate my willingness to continue with the experiment by signing the form. Before proceeding, I will receive a copy of the form to keep if I wish.

Driving Simulator Practice Session: During the practice session I will be provided an information sheet about the simulator and instructions on performing the practice session. This practice session will provide the opportunity to become familiar with driving the simulator and will last approximately five minutes.

Driving Simulator Experimental Session: During the simulator portion of the experiment, I will be asked to drive through a simulated driving environment, and respond to the different signs and traffic conditions as I normally would when driving my own vehicle. This portion of the experiment will take approximately 30 minutes.

Questionnaire: Following the experiment, I will be asked to complete a questionnaire to provide demographic information about myself, as well as some information pertaining to my driving.

Debriefing: Before leaving, I will be provided a debriefing sheet that explains the purpose of the study in full.

INFORMED CONSENT: Page 2 of 2

I understand that the only risk associated with this study is a temporary condition named 'Simulator Induced Discomfort' (SID) which is characterized by feelings of dizziness and increased body temperature. The potential for this discomfort is minimal as it only mildly affects about 10 persons out of every 100 under the driving conditions. I understand that I am to indicate to the investigator if I experience any of these symptoms, and that the study will be stopped to prevent any further discomfort to me. I understand that it is my right to stop the study at any time for any reason without any repercussion. If I ask to stop the study because I am not feeling well, I will still receive full payment for participation.

Confidentiality: I understand the records of this study will be kept private. In any sort of report that might be published, no information will be included which may make it possible to identify me. I understand the research records will be kept in a locked file, accessible only to the investigator. I will be asked to sign a form acknowledging payment for my participation. These forms are kept separate from this signed consent form and any other data that would identify me by name.

Voluntary Nature of the Study: My decision whether or not to participate will not affect my current or future relations with the Texas Transportation Institute, Texas A&M University, or the Texas A&M University System. If I decide to participate, I am free to withdraw at any time without affecting those relationships.

Contacts and Questions: The researcher conducting this study is Susan T. Chrysler, Ph.D. If I have questions now or later, I may contact Susan T. Chrysler at the Texas Transportation Institute, Texas A&M University, College Station, TX 77843-3135, (979) 862-3928.

I will be given a copy of this form for my records.

A copy of this form will be given to me if I wish to keep one.

This research study has been reviewed and approved by the Institutional Review Board - Human Subjects in Research, Texas A&M University. For research-related problems or questions regarding subjects' rights, the Institutional Review Board may be contacted through the IRB Coordinator, Office of Vice President for Research and Associate Provost for graduate Studies at (979) 845-1811.

Statement of Consent: *I have read and understand the explanation provided me. I have had all my questions answered to my satisfaction, and I voluntarily agree to participate in this study. I have been provided a copy of this consent form.*

Signature of Research Participant

Date

Signature of Principal Investigator

Date

Instructions

Note: Instructions for the video and PowerPoint methods were much similar, informing the subject of their destination, and asking them to not turn the page until instructed. Since these methods did not contain a practice session, there were only one set of instructions. The other instructions can be obtained by the first author.

PRACTICE SESSION INSTRUCTIONS

You will be seated in the car in the driving simulator room. This is an interactive simulator, which means the driving scenes you see react to your steering and pedal inputs to provide a realistic driving experience, including a working speedometer. The simulator does not move, but there are stereo speakers that make it sound like you're really driving. There is a microphone in the car and you can speak to the experimenter at anytime. The experimenter will be in the room at all times and can speak to you through the car radio.

During your drive in the simulator, please drive in a normal fashion and obey all traffic laws, including speed limits. Pay close attention to traffic signs. Respond accordingly to all relevant traffic signs and on-screen instructions. Due to the resolution limitations of the projection equipment, signs may appear to "flicker" off in the distance. However, if you drive at appropriate speed limits the signs will become legible as you approach them. We would like you to generally stay in the right-most lane, just like you should in the real world. Occasionally, you may need to change lanes due to changes in the number of lanes on the freeway, road construction, accident scenes, and to take or avoid exits at freeway interchanges. When you feel it is necessary and appropriate to change lanes, please remember to use your turn indicator. You can assume that there are no other cars in your blind spot.

For the practice session your task is to get comfortable with driving in a simulated driving environment. The scene will be a freeway going through a city. You will start pulled off onto the shoulder. Please put the car into "Drive" and pull out onto the freeway as normal. Feel

free to experiment with the steering, brake and accelerator pedals during this practice sessions. We want you to get the feel for the car. The practice session will take approximately five minutes. When you feel that you are comfortable and ready to start the experiment you can end the practice session yourself. You will occasionally see a large flashing green arrow floating over the edge of the roadway. If you pull over and drive slowly through the arrow you will automatically be placed at the beginning of the experimental scene. Please wait there for further instructions from the experimenter.

Once you've begun the experiment, at various spots along the way, you will be instructed to briefly pull over to the side of the road to answer a few questions about the signs you have encountered. A text message will appear at the top of the screen asking you to pull over. You will have a clipboard in the car which contains the questions. Once you've stopped, pick up the clipboard and answer the appropriate questions instructed by the experimenter. Please leave your foot on the brake when you stop, or put the car in park.

The following is an example of the questions you will be asked:

Practice Question (circle the correct response)

What does this sign mean?

- 1) There is a busy cross street ahead.
- 2) There is two-way traffic ahead with no divider between the lanes.
- 3) The flow of traffic ahead will reverse directions.
- 4) I am not sure what that sign means.
- 5) I could not read the sign.
- 6) I did not notice the sign.



Tips to Reduce Simulator Induced Discomfort

- Maintain focus on roadway ahead of you.
- Do not turn head for any extended period and focus on peripheral screens.
- If you begin to feel uncomfortable, you can open the car door and continue driving with the door open and one foot planted on the ground.
- A “sea band” (wristband) can be requested and worn to prevent motion sickness.
- If the discomfort becomes unbearable, please alert the experimenter.
- If you find that you are getting hot, swallowing frequently, or are perspiring more than usual, these may be early signs of sickness. Please let the experimenter know right away by speaking up or pulling to the side of the road. Again, there is no penalty for stopping early.

Any Questions?

EXPERIMENT INSTRUCTIONS

Now it's time to start the experiment!

- Your task is to drive to the city of Rico. Your starting point will be on Interstate 87 approximately 15 miles from Rico. You will need to pass through the city of Forest Hills to Interstate 27 to get to Rico. The road signs along the way should give you enough information to get there.
- In general, you should drive in the right-most lane.
- Remember to indicate any lane changes by using your turn signal.
- If you happen to miss a sign or an exit, do not worry. Simply tell the experimenter and you will be instructed on how to get back on course.
- Please keep your comments and other conversation to a minimum. The experimenter will be glad to discuss your experience and answer any questions following the experiment.
- If you are feeling any discomfort or motion sickness, let the experimenter know right away

Any Questions?

Full Questionnaire for the Driving Simulator Method

Note: The actual question packets contained one question per page.

Question #1. What is the meaning of the last sign you passed on your right?

- 1) The median between opposing traffic will end.
- 2) The lane ends and traffic in the left lane should move into the right lane.
- 3) There is a single lane ahead for both directions of traffic.
- 4) The lane ends and traffic in the right lane should move into the left lane.
- 5) The lane you are in will become narrower.
- 6) I am not sure what that sign means.
- 7) I could not read the sign.
- 8) I did not notice the sign.

Question #2. What is the meaning of the last sign you passed on your left?

- 1) Lane changes are not permitted.
- 2) The left lane is for making left turns only.
- 3) Left turns are not permitted.
- 4) I am not sure what that sign means.
- 5) I could not read the sign.
- 6) I did not notice the sign.

Question #3a. What is the meaning of the last sign you passed on your right?

- 1) The speed limit will be higher ahead.
- 2) The speed limit ahead will be strictly enforced by the police.
- 3) The speed limit will be lower ahead.
- 4) I am not sure what that sign means.
- 5) I could not read the sign.
- 6) I did not notice the sign.

Question #3b. What is the meaning of the last sign you passed on your left?

- 1) This lane is for highway official's vehicles only (law enforcement and emergency response).
- 2) This lane is for high occupancy vehicles only (carpools and buses).
- 3) This lane is for heavy, oversized vehicles only (mobile home transports and double long semi-trucks).
- 4) I am not sure what that sign means.
- 5) I could not read the sign.
- 6) I did not notice the sign.

Question #4. What is the meaning of the last sign you passed on your right?

- 1) There is a single lane ahead for both directions of traffic.
- 2) The median between opposing traffic will end.
- 3) The lane ends and traffic in the left lane should move into the right lane.
- 4) The lane ends and traffic in the right lane should move into the left lane.
- 5) The lane you are in will become narrower.
- 6) I am not sure what that sign means.
- 7) I could not read the sign.
- 8) I did not notice the sign.

Question #5. What city will you go to if you continue on Interstate 87?

- 1) Delta
- 2) Rockville
- 3) Fort Springs
- 4) Rico
- 5) Riverdale
- 6) I wasn't paying attention to other cities.
- 7) I do not remember.
- 8) I am not sure what that sign means.
- 9) I could not read the sign.
- 10) I did not notice the sign.

Question #6. What is the meaning of the last sign you passed on your right?

- 1) If you are in the center lane, you will be required to make a left turn at the next intersection.
- 2) Travel in the center lane is allowed, but right turns are not.
- 3) Do not use the center lane for any purpose other than to make a left turn.
- 4) I am not sure what that sign means.
- 5) I could not read the sign.
- 6) I did not notice the sign.

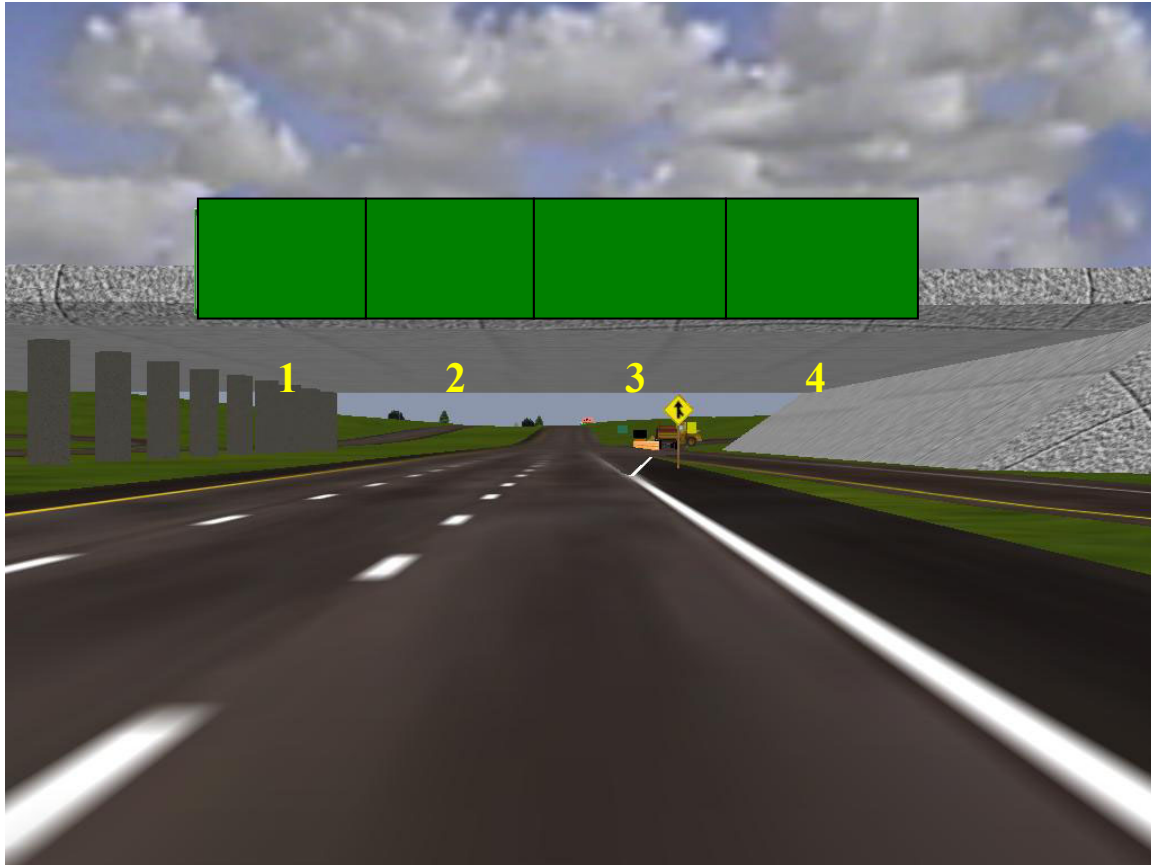
Question #7. What is the meaning of the last sign you passed on your right?

- 1) The speed limit ahead will be strictly enforced by the police.
- 2) The speed limit will be lower ahead.
- 3) The speed limit will be higher ahead.
- 4) I am not sure what that sign means.
- 5) I could not read the sign.
- 6) I did not notice the sign.

Example Questions from the Remaining Method Questionnaires

Note: All of the Questionnaires used the same multiple choice questions and responses, except that verb tense changed between some of the methods. For the questions concerning lane change responses, signs were used to identify the lanes numbers. Examples of these are below. The entire questionnaires for any of the methods can be obtained by contacting the first author.

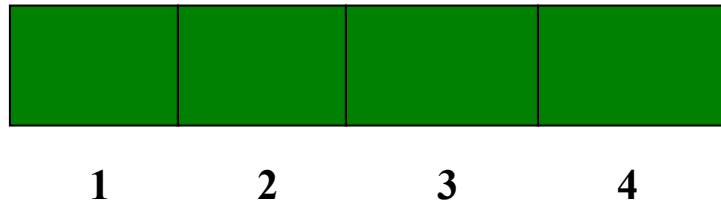
Question#6 (From the Video or PowerPoint-Screen Prints Methods)



What Lane would you get in to drive towards Rico?

- 1) 1
- 2) 2
- 3) 3
- 4) 4
- 5) I wasn't paying attention to the cities
- 6) I do not remember
- 7) I am not sure what those signs mean
- 8) I can not read the sign
- 9) I did not notice the sign

Question#6 (From the PowerPoint- Signs Only Method)



What Lane would you get in to drive towards Rico?

- 1) 1
- 2) 2
- 3) 3
- 4) 4
- 5) I wasn't paying attention to the cities
- 6) I do not remember
- 7) I am not sure what those signs mean
- 8) I can not read the sign
- 9) I did not notice the sign

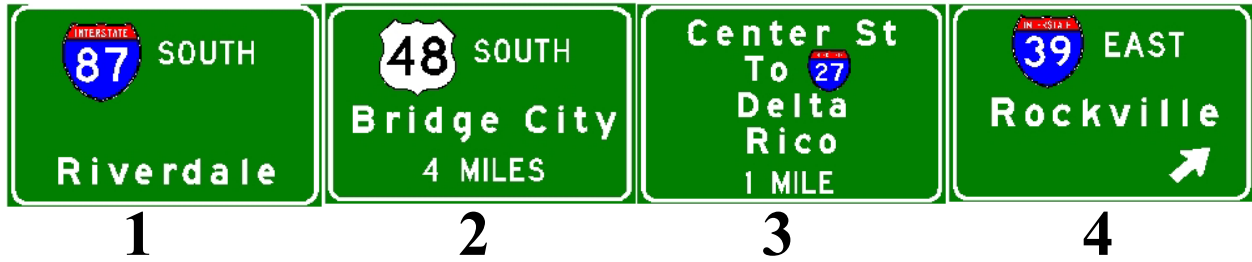
Question#6 (From the Paper – Screen Prints Method)



What Lane would you get in to drive towards Rico?

- 1) 1
- 2) 2
- 3) 3
- 4) 4
- 5) I wasn't paying attention to the cities
- 6) I do not remember
- 7) I am not sure what these signs mean
- 8) I can not read the sign
- 9) I did not notice the sign

Question#6 (From the Paper – Signs Only Method)



What lane would you get in to drive towards Rico?

- 1) 1
- 2) 2
- 3) 3
- 4) 4
- 5) I wasn't paying attention to the other cities
- 6) I do not remember
- 7) I am not sure what those signs mean
- 8) I can not read the signs
- 9) I did not notice the sign

Driving Simulator Debrief Information

Note: The Debriefing sheets for the video and PowerPoint methods were similar very similar to the one below. The other sheets can be obtained by contacting Dr. Susan Chrysler at 936-862-3928.

Post –Experiment Debriefing Information

Thank you for participating in this experiment. The purpose of the experiment is to evaluate the effectiveness of different methodologies that assess traffic sign comprehension. As new signs are introduced onto Texas roadways, it's important that drivers understand them. Currently, and in the past, researchers test whether or not people understand traffic signs by showing them either photos or drawings of the signs. This experiment will compare these methods to testing that takes place while people are driving in the simulator. It's cheap and fast to use drawings of signs, but this unrealistic way of testing may be biasing the results since in the real world you see a sign for a short time in a roadway context.

You were in the simulator group of our study. We will look at the answers you gave to the multiple choice questions. We will also look to see where and when you used your turn signal to indicate a lane change, how fast you drove, and which lane you were driving in. We will test a different group of people later this semester by showing them a videotape of the driving scene through which you just drove. Another group will be tested after only seeing drawings of the signs. By comparing performance across the different groups we will be able to see if there is any difference between the presentation materials used in the research. If the group that looked at drawings does the same as the group who drove in the simulator, future research could use the less expensive method.

Again, thank you for participating. All of your results will be reported only as group averages. Any personal information will be removed and kept separate from your actual performance measures.

If you would like a copy of the results of this study or have any questions concerning your participation please write or call the Human Factors Program of the Texas Transportation Institute at Texas A&M University.