INVESTIGATING THE ROLE OF DRIVER DECISION STYLES IN HIGHWAY-RAIL CROSSING ACCIDENTS

FINAL REPORT
METRANS Project 00-11

December 2003

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ABSTRACT

This research was designed to take a closer look at the ways by which driver decision-making styles affect highway-rail crossing (HRC) accidents. That is, a simplistic approach of portraying human error, as the cause of most HRC accidents, needs to be augmented with a more complex theory of human decision-making process while performing driving tasks before and during a highway-rail intersection. Video and still photos were taken to identify the intersections appropriate for this study. The intersections were among many in the Los Angeles metro area with crossings that demanded certain driver maneuvers with potential accident consequences. Based on these selections, both field and laboratory experimental sessions were designed to study three sets of variables: driver decision styles, conditions in the intersection environment that could influence these decisions (environmental complexity) and the driver maneuvers to cross the intersection. The variable of distraction inside the crossing intersection was also studied using recall versus recognition tests. The parametric tests (analysis of variance) showed significant differences in the drivers' scores for the decision style variable. However, other variables showed no significant results. The same results were shown using the chi-square nonparametric test. These results showed that driver decision style is an important factor in the way drivers perceive and behave in highway-rail crossings. Further research was recommended to study the effect of each intersection design feature on driver behavior.

TABLE OF CONTENTS

LIST OF TABLES

DISCLOSURE

Funding Source:

METRANS Transportation Center, USC/CSULB

Names of principal investigators:

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Total Dollar Amount:

$88,062

Title of Project:

Investigating the Role of Driver Decision Styles in Highway-Rail Crossing Accidents

Relationship to report:

The Principal Investigators wrote the report and are responsible for its contents.

Subcontract statement:

This project was funded in entirety under this contract to California Department of Transportation

ACKNOWLEDGEMENTS

This research was entirely supported by USC/CSULB Metrans Center, its funding agencies, the Department of Transportation and California Department of Transportation.

The research team thanks the Los Angeles Metropolitan Transit Authority (MTA) and its associated agencies for providing valuable information throughout this research. We would especially like to express our appreciation to Abdul K. Zohbi, Vijay Khawani, Essam Aly, Anthony Loui, Paul J. Lennon, and Roger Snoble for taking time from their busy schedules to meet with us, provide information and answers to our queries. The support of MTA contractor, Mr. Jim Curry of Parsons, Brinckerhoff Quade & Douglas is also appreciated.

We express our gratitude to the following individuals for explicitly expressing their support of our research on grade crossing safety: Ms. Yvonne Brathwaite Burke, Supervisor of the Second District, County of Los Angeles, and her assistant, Mr. Michael Bohlke; Congresswoman Diane E. Watson and her assistant, Mr. Jim B. Clarke; Mr. Angelo J. Bellomo, Director of the Office of Environmental Health and Safety, Los Angeles Unified School District; and Dr. Thomas G. Raslear of the Office of Research and Development, Federal Railroad Administration.

We would like to express our gratitude to our USC colleagues, including professor Kurt Palmer for his advise concerning statistical analysis; professors Genevieve Giuliano, Randolph Hall, James E. Moore, II for their support of transportation safety and this research project; and to Ms. Christine Lavoie, former USC Metrans administrator.

Lastly, we would like to thank our graduate assistants, Ms. Sahar Shayesteh-Mehr and Mr. Kidra Shadroo, and our undergraduate student assistants, Ms. Laurel Chen, Mr. William Murphy, Mr. Joseph Deato, and Mr. Faysal Al-Hashem for their help in this research. They were instrumental in conducting the field data collection and videotapes, experimental setup and data collection in our laboratory, and reducing the data for further analysis.

1. INTRODUCTION

> "Every grade crossing is an accident waiting to happen."
> David Solow, Executive Director of the Southern California Regional Rail Authority (Metrolink) (*Los Angeles Times*, September 9, 2003, p. B4)

Railroad crossing accidents pose a serious safety problem in the United States for all communities. Each year, highway-rail crossing (HRC) accidents cost society about 1.8 billion dollars in medical costs, insurance payments, legal fees, and damages to railroad property (Meeker, 1997). Unfortunately, such collisions occur at all types of HRCs, including those from modern inter-city commuter systems such as the Los Angeles Metrolink.

There is on average a collision between a train and a vehicle every 90 minutes in the U.S. According to a recent report by the National Transportation Safety Board, more than 4,000 accidents have occurred at the Nation's active and passive grade crossings each year from 1991 through 1996. California logged 131 accidents and 67 deaths involving pedestrians or vehicles at street crossings in the first six months of 2003, according to the Federal Railroad Administration. The numbers for the same interval last year were 144 incidents and 65 fatalities (*Los Angeles Times*, September 9, 2003). "In 2002, there were over 3,000 accidents with 356 fatalities at grade crossings," said the National Transportation Safety Board (NTSB) Chairman Ellen G. Engleman at a NTSB hearing on December 2, 2003. She continued: "They can be prevented if we are vigilant and aggressive in pursuing needed safety improvements."

The number of fatalities on street-level light rail crossings in the Southland has reached an alarmingly epidemic proportion. Sixty-five people have died on the Metropolitan Transportation Authority's (MTA) 60 miles of light railways in Los Angeles since 1990. On the Southern California Regional Rail Authority's 512-mile "Metrolink" system, 31 people have died in the last ten years, four of which were in January 2003. A few of these cases were suicide, but a vast majority of the dead were drivers and pedestrians who inadvertently crossed the tracks and were hit by the moving trains.

The 22-mile L.A.-Long Beach Blue Line has had more than 620 accidents (95% of the total MTA accidents) and had "the highest light rail accident rate" in the state during the 1990s. According to the California Public Utilities Commission (CPUC) and the Federal Transit Administration it is among the deadliest railways in the nation. These are particularly troublesome because currently the Blue line is the only significant above ground rail line in the MTA system with heavy street intersections. (The Green Line is the other major above ground light rail line, but it passes down the center of the 105 Freeway and does not cross over arterial streets.) With all of this tragedy, what will happen as Los Angeles' above ground light rail system grows? The Blue Line's path has a lot in common with the new Gold Line light railway that started running in June 2003 on its 14-mile track. It is passing through densely populated neighborhoods between downtown Los Angeles and Pasadena. According to the *Los Angeles Times* (November 25, 2003), “a roughly half-mile segment of the Gold Line running down Marmion Way in Highland Park is one of the most worrisome stretches of railway for the MTA. Gold Line trains run through the middle of a narrow street, no more than 30 feet from the front doors of many homes.”

The same concerns loom over the Exposition Light Rail that the MTA is planning to build on the vacant Right of Way median of the Exposition Blvd. Once entirely completed, it will connect Santa Monica to Downtown, will intersect major busy streets such as La Brea and Crenshaw, and will call for the establishment of a total of 10 stations at specific locations and intersections. It will pass by especially vulnerable populations, which include the students of 22 schools adjacent to the rail line, as well as the sizable elderly population who live around Exposition Blvd.

PREVIOUS RESEARCH ON HRC SAFETY

Railroad safety engineers strive to provide grade crossing systems in which lights, bells, and gates are activated with sufficient lead-time to accommodate the fastest train, the slowest driver, and the worst environmental condition. Twenty years ago, only about 50,000 of the country’s 225,000 public grade crossings were protected by flashing lights, bells and/or gates that drop down when a train is about to pass. Today, there are about 62,000 of these active crossings out of 154,000. Such active warning systems are expensive -- even simple ones can cost $150,000 to install. And active crossings have human-factors problems of their own, which may help explain why they account for half of all grade-crossing collisions (*Los Angeles Times*, November 20, 2003).

However, these designs fail to consider the inherent limitations of human judgment and decision-making in a potentially hazardous crossing event. Over 50% of crashes at public crossings occur where active warning devices such as gates, lights, and bells exist and function properly. More surprisingly, about 70% of these collisions occur when the train is traveling less than 40 mph (Highway-Rail Crossing and Trespasser Facts, 1/11/00). Some of the HRC accidents that fall in these categories have been attributed to the driver’s disregard for the stop sign, failure to look for a train, distraction, judgment error, inattention, failure to follow procedure, fatigue, or drug impairments (NTSB, Safety at Passive Grade Crossings: Volume 2 – Case Summaries, 1/22/00). One study shows that as warning time increases, the percentage of railroad crossing violations also increases (Carlson and Fitzpatrick, 1999). In other words, the longer a driver has to wait before a visual contact with the train, the more likely he/she will attempt to drive around the gates or through flashing lights.

An in-depth look at the literature in this area has revealed a number of influential factors in HRC cause-effect relationships. A HRC accident report of the Los Angeles County Blue Line has detailed sixteen “contributing factors” for their accidents (LAC/MTA, 1999). Among these factors, the ones least studied appear to pertain to the "human factors" of HRC accidents. The significance of these causal factors was shown by Wilner (1998) who reported that over one-third of rail accidents and 80% of train collisions are caused by human error. Moreover, a study in Japan looked at HRC accidents in a comprehensive and multi-factorial approach. (Anandarao and Martland, 1998). Based on their classification, it was found that the leading cause of the crossing accidents was the driver's "Ignorance of Warning." It is plausible that they did not notice the warnings in time to stop. Nevertheless, in many cases, a major factor could also have been the driver's choice to ignore the warning and voluntarily enter the crossing.

Therefore, it is critical to analyze driver behavior and decision-making as well as the interaction of these variables with the engineering design of the crossing (Rahimi and Meshkati, 2001). By adding these to a generic model of HRC accidents (suggested by Tustin et al., 1986), we see a large number of influential factors classified as: vehicle (size, maintenance), highway (surface, geometry, traffic load, environmental conditions), driver (risk perception, reaction time), train (speed, flagging, brake time), and crossing feature (warning systems, visibility, trespassing, enforcement).

The current safety technologies seem to have been saturated and are ineffective in significantly reducing HRC accidents. In the mid-1980s, we began to see strong connections between the theories of cognition and human information processing and transportation-related accidents. Many of these studies hinted at the complexity of interactions between driver cognition and visual perception versus vehicle design and roadway/crossing conditions. For example, a driver may overestimate the safe time interval for crossing the tracks because of misleading visual cues (Rahimi, 1989; Rahimi et.al, 1990; Leibowitz, 1985). Studies have shown that for vehicles of equal velocities, the larger the object, the slower the perceived velocity (a notion called "expansion of optical array"). This leads drivers to underestimate the speed of an approaching train. Also, monocular cues such as rows of trees or telephone poles lining a track create the illusion that the train is farther away than its actual position. Overall, the illusion of velocity and size (inverse relationship), the illusion of perspective, and the deceptive geometry of collisions (inverse expansion pattern) all cause drivers to overestimate the safe time interval. Studies have also shown that time-to-collision estimates are more accurate with a normal vision field, binocular vision, higher speeds, and driving experience (Viola, 1988).

Also, a number of NTSB accident reports hint at the possibility that drivers are given insufficient indicators for an approaching train. For instance, according to the NTSB (December 2, 2003), the probable cause of the collision earlier this year between a commuter Metrolink train and a truck in Burbank, CA, which also caused the train derailed, was "the design of the traffic signals' railroad hold interval, which displayed a flashing red arrow for the eastbound North San Fernando Boulevard left turn lane onto North Buena Vista Street." Moreover, according to the NTSB's investigation, "the accident driver lost situational awareness in an ambiguous and confusing environment that required significant mental alertness and vigilance; consequently, he missed the cues alerting drivers to an approaching train."

Warning cues, roadway or track conditions, and sun glare affecting visibility can contribute to these accidents. Warning signals could also be improved to provide additional visual cues to drivers, like the two new crossbuck railroad sign designs utilizing microprismatic sheeting materials, which have already been evaluated in Ohio (Zwahlen and Schnell, 1999). These signs have been successful in increasing the light reflection and visibility for drivers. However, even the most successful device is faced with a resistance for implementation on a large scale (Barry, 1999).

Recently, efforts have been made to utilize advanced technologies and intelligent systems. Computers, digital data communications, and other advanced technologies can help manage and control the railroad, locomotives, maintenance, inspection efforts, and elements of the railroad infrastructure. For example, electronic train monitoring and control systems could display operating instructions governing safe train movement from train dispatchers to train crews in the locomotives. In addition, automated enforcement at lowered crossing gates could use sensors to detect violators and photograph the violator's license plate (see LAC/MTA, 1997, for a detailed description of photo enforcement at the Long Beach Blue Line Grade Crossing). There have also been efforts to further develop In-Vehicle Alert System (Wanat, 1/21/00), Vehicle to Roadside Communication (Kady, Mark, Shloss, and Peter, 1995), Intelligent Vehicle Initiatives for railroads (IVI), and the Vehicle Proximity Alert System (VPAS). These systems are being designed and evaluated to detect the presence of on-coming trains through sensors and broadcast that information inside specially-equipped vehicles using visual displays and voice capacities (1997 Projects Book, 2/1/00).

In this project, we propose that the decision styles of the drivers have a significant impact on the way in which the HRC actions are motivated. Decision styles are the way by which individuals receive, store, process, and transmit information for action. By decision style we mean: (1) the manner in which the driver reacts to a given crossing situation, or (2) the manner of interaction with other elements of the environment. This approach suggests that environmental variables (e.g., time pressures and mental load) affect the complexity of information processing behavior of the driver. In this respect, the decision-making differs among drivers in two key dimensions: amount of information used and number of decisions made. The Driver Decision Style is evaluated by a "paper and pencil" instrument, which has been used by 400,000 individuals.

We have accomplished the above goal(s) by designing experiments based on actual crossings from down town Los Angeles (please refer to Appendix A for copies of experimental procedures, trails, tasks, and Appendix E for an electronic version of video clips). We analyzed the effect of drivers' individual information processing behavior and decision styles on handling different grade crossings plus their performance on recalling the crossing conditions while they made the decision to cross.

Based on this research, it is concluded that: Drivers' individual decision styles and the combination of their styles play an important role in making decision concerning to cross or not to cross under different environmental conditions and time pressure situations.

INFORMATION PROCESING BEHAVIOR: THE DECISION STYLE MODEL

Cognitive styles are defined as learned thinking habits, which act as indices to the individual's total personality system, its functioning, and development. Thus, they are collectively representative of the individual's conceptual structure (i.e., the way he/she receives, stores, processes, and transmits information). By analyzing these cognitive styles, behavioral variations and individual differences of decision makers can be explicitly identified and analyzed (Driver, 1983). By employing the above concept, Schroder, Driver, and Streufert (1967), and Driver and Streufert (1969) developed a human information processing model.

This model suggests that environmental pressures (or load) systematically affect the complexity of information processing in persons in an inverted-U-shaped function. Each individual can be considered to have a unique and consistent "curvilinear information-use pattern," referred to as their *decision style*. Every individual has acquired at least one basic or "dominant" decision style that is normally exhibited under moderate environmental load. For most people, a second or "backup" style emerges in extreme environmental load conditions, such as uncertainty and time pressure. Environmental load is defined as the sum of the effects of four basic factors: (a) information complexity (e.g., information load, time pressure); (b) "Noxity" or negative input (e.g., threat); (c) "Eucity" or positive input (e.g., support from others); and (d) uncertainty (Driver, 1979).

The decision style model is based on two primary dimensions: information use and focus. Information use refers to the amount and complexity of information actually used in thinking and decision-making. Focus is defined as the number of alternatives, which are contained in the final solution, reached. Focus is a continuous dimension ranging from unifocus, in which a single alternative forms the outcome, to multifocus, in which many different options are included in the final solution. The unifocus style takes a given amount of data and connects it around a single solution or decision alternative, whereas the multifocus style takes the same amount of data and integrates it into several outcomes simultaneously or within a very short time.

The information use dimension can be split at some point between two extremes; at one extreme are those individuals who habitually use as much non-redundant information as is available, termed "maximizers." At the other extreme are those individuals who use just enough information to generate one or two useful alternatives, termed "satisficers." The maximizer/satisficer dimension suggests a high vs. low degree of integration, or the type and amount of connections between information units during analysis. By combining the dimensions of focus and information use, five distinct decision styles can be recognized: "Decisive" (unifocus, satisficer), "Hierarchic" (unifocus, maximizer), “Flexible” (multifocus, satisficer), “Integrative” (multifocus, maximizer), and “Systemic” (combination of Integrative and Hierarchic) (Driver, Brousseau, and Hunsaker, 1993).

The decision style model has several implications for decision-making in a naturalistic milieu and in time-pressured tasks. For instance, in mental task performance, different styles consistently demonstrate distinctively <u>different</u> reactions (e.g., perceived difficulty) to the same task load level and environmental demands, as reported by Meshkati and Driver (1984), and Meshkati and Loewenthal (1988).

INFORMATION COMPLEXITY AND UNCERTAINTY

Just as there are marked differences in the decision style of individuals or teams, many differences can be seen in the degree of complexity that individuals are motivated to utilize in their decision making (Schroder, Driver & Streufert, 1967). In general, complexity motivation is the degree to which individuals are driven to use a variety of information, skills, and methods in the process of completing a task. Information refers to either sheer volume or the rate of information per time unit.

The other component is the differentiation or the number of types of information that are used in an information network. At one extreme are individuals who prefer to keep the process simple by working with a limited amount of information and number of methods. At the other extreme, some individuals prefer a high degree of complexity, actively seeking a myriad of kinds and sources of information as well as a variety of techniques to complete their jobs.

A second complexity motive is the need for order as compared to uncertainty, defined as the uncertainty motive. Some individuals require a high degree of structure, order, and feedback while others thrive on novelty, ambiguity, risk or conflict.

Individuals seek to balance their desired level of complexity/uncertainty and the actual level of complexity/uncertainty that their work requires. In areas where the desired level of complexity is lower than the actual complexity required, individuals are considered to be experiencing “strain.” In areas where the desired level is higher than the actual complexity required individuals are said to operate under a “growth” situation. In areas where the two match, individuals are said to be in balance. Similarly, individuals can experience levels of strain, growth, or balance with regard to their uncertainty motive.

2. MTHODOLOGY AND STATISTICAL ANALYSIS

The primary objective of this research is to explore the relationship between the decision styles of drivers versus their highway-rail crossing behavior. In order to accomplish this objective, a number of statistical analyses were performed, as described below.

ANALYSIS OF VARIANCE

Analysis of variance (ANOVA) is a statistical tool that defines the impact of several independent variables on a dependent variable, in an experimental design format. For this analysis, we defined a number of variables associated with the design of HRCs and sought to measure their impacts on driver decision styles.

After studying the literature and interviewing a number of experts from MTA, we have defined two variables as the most influential in this respect. These variables were labeled as "time pressure" and "environmental complexity." Other variables studied, but not considered for this experiment, were familiarity of the drivers with the intersection, speed of vehicle, and acceleration and deceleration of the train. The decision style variables have been discussed in the previous sections.

In our study, time pressure refers to situations in which drivers at an HRC are under strict time constraints and are thereby forced to form their decisions quickly and efficiently. Environmental complexity encompasses a variety of factors, including intersection complexity, traffic congestion, and distractions in the environment viewed by the driver. As explained below, time to completion was considered as a measure of time pressure and signal to noise ratio was used as a measure of environmental complexity.

ANOVA Design

We designed our ANOVA to have four levels for the decision style (DS) variable and two levels for environmental complexity (EC) variables. Within two levels of EC, we have nested two levels of "low" versus "high" to differentiate the degree by which these EC variables are measured. This gives us a 2x2x4 mixed (nested) ANOVA table below.

Table 1. ANOVA Table for the Experimental Trials

Decision Style	Time Pressure		Environmental Complexity	
	Low	High	Low	High
Decisive				
Flexible				
Integrative				
Hierarchical				
Systemic				

The mixed design indicates that we have within-subjects variability for EC levels and between-subject variability for Low versus High levels. The subjects were shown approximately 20 seconds of video footage of trains passing by on the left-hand side of the screen, to accustom them to the notion that trains are present in these intersections. Then, they were shown video footage of the different scenarios and their responses were monitored.

Defining Time Pressure

Two scenarios were created for time pressure, low and high. In the low time pressure footage the subjects watched a traffic light in the intersection that stayed green while a vehicle in front of the driver pulled into the left lane, in preparation for a left-turn on the signal. The front vehicle turns left and the experimental vehicle follows, making a simple left-turn across the HRC. We note that "left-turn" across HRCs are the most accident prone maneuvers by automobile drivers. In this setting, the subject is under very little time pressure when making his/her decision to turn left. In the high time pressure footage the subjects viewed a vehicle in front of the experimental vehicle at time 0 seconds while the left turn arrow light was green. At time 1 second, the light turned yellow, while the vehicle in front began moving into the intersection for a left-turn. At time 2 seconds, the front vehicle completed a left-turn while the light stayed yellow. Meanwhile, the experimental vehicle moves up to the stop line. At time 3 seconds, the left turn arrow turned red and the vehicle in front had completed its left-turn. Some drivers in this situation, have reported difficulty making a decision whether to cross or not – potentially a source of HRC accident in some left-turn situations. For these two scenarios, we measured the time it takes for the subject to make the decision to cross.

Post-Experiment Questions

After the video footage for the time pressure scenarios were shown to the subjects and their measures were taken, the subjects were asked to draw the intersection they just observed in the video on a piece of paper. They were told to draw all objects they remembered from the scenes. We were specifically interested to see whether they remembered the sign panel which contains the flashing train picture, the left-turn arrows, the left turn sign, and traffic lights for through traffic, and bar indicators showing the direction of traffic movement. They were then given a questionnaire including questions such as:

- What signs did you pay attention to?
- Do you know the meaning of each sign and its purpose?
- Which signs give indications that are important to you?

From literature we knew that drawing the scene causes the subject to use their recall memory, while identifying the purposes of the signs calls upon recognition memory. The recall scene is a simple drawing of the intersection with all objects in the scene in place. The recognition scene is a drawing of the scene with some of objects in place. The subjects were asked to add items of importance in this scene. The questionnaires are included in Appendix A.

As explained above, the tests have been designed for four different scenarios based on four experimental situations. Every situation was considered to measure the impact of time pressure (TP) and environmental complexity (EC). Each time and environmental complexity variable was divided to two statuses as low and high to have a spectrum with high and low limits and were defined as HTP (High Time Pressure), LTP (Low Time Pressure) and HEC and LEC for high and low environmental complexity.

Defining Environmental Complexity

The following table shows high and low criteria for environmental complexity. For example a HEC intersection contained all marked objects under that column (e.g., light pedestrians, trees, sidewalks, etc.).

Table 2. Objects in Intersections (Low vs. High Env. Complexity)

Objects	LEC	HEC
Pedestrians		✓
Vehicles		✓
General signs	✓	✓
Traffic direction	✓	✓
Vendors		✓
Buildings	✓	✓
Number of lanes of through traffic	✓	✓
Number of lanes of perpendicular traffic	✓	✓
Lighting poles	✓	✓
Trees	✓	✓
Signal poles	✓	✓
Cross walk	✓	✓
Sidewalk	✓	✓
Train-related signs	✓	✓
Train station		✓
Passing train		✓
Train tracks	✓	✓

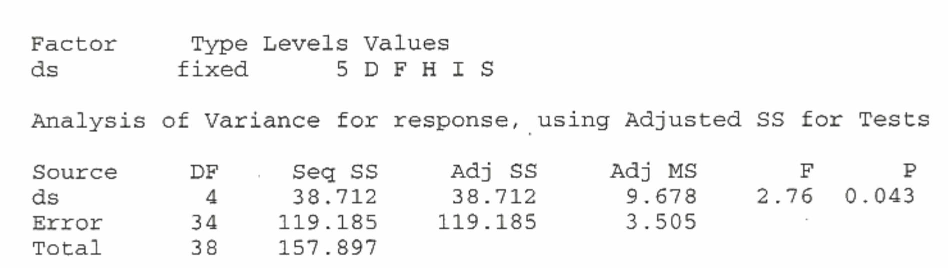
In order to choose which intersections represented these conditions the best, we videotaped a large number of HRC intersections in downtown Los Angeles. More than twenty hours of videotapes were analyzed for these criteria. In addition to the above criteria, other parameters such as number of accidents in those intersections were taken into account. We used MTA's Metro line data to match accident statistics with the assigned intersections. For instance, the intersections we taped were among the top three ranked intersections in terms of their incident rates from July 1990 to March 2000 (*Summary of Metro Blue Line Train/Vehicle and Train/Pedestrian Accident* May 19, 2000 Prepared by Risk Management Dept.). The final selection for LEC was the intersection of Los Angeles Street and Washington, and the HEC was the intersection of Grand and Washington. The direction of light train moving was East/West along the Washington Street. We then simulated our scenarios based on these intersections and videotaped them for our experimental setup.

We videotaped the actual live scenes from inside an automobile, while crossing a high-incident intersection in downtown Los Angeles. A camera was mounted at the driver's eye level and taped the subject's actual visual scene while driving a vehicle. For the experimental setup, each session playback represented a cell within our nested ANOVA design. Post-experiment questionnaires are shown in the Appendix A for the four conditions of LEC, HEC, LTP, and HTP.

ANOVA Results

We used Minitab statistical software to compute the F-ratios for each ANOVA. The following tables contain the results of the analysis in the form of Minitab output tables.

Table 3. The effect of Decision Style, LEC, and Recall

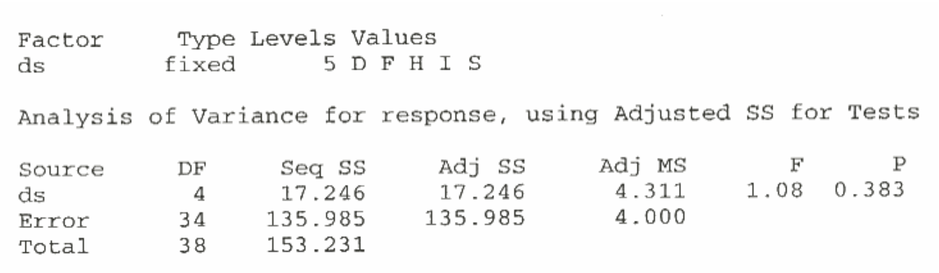


```
Factor     Type Levels Values
ds        fixed      5 D F H I S

Analysis of Variance for response, using Adjusted SS for Tests

Source      DF     Seq SS     Adj SS     Adj MS       F      P
ds           4     38.712     38.712      9.678    2.76  0.043
Error       34    119.185    119.185      3.505
Total       38    157.897
```

Table 4. The effect of Decision Style, LEC, and Recognition

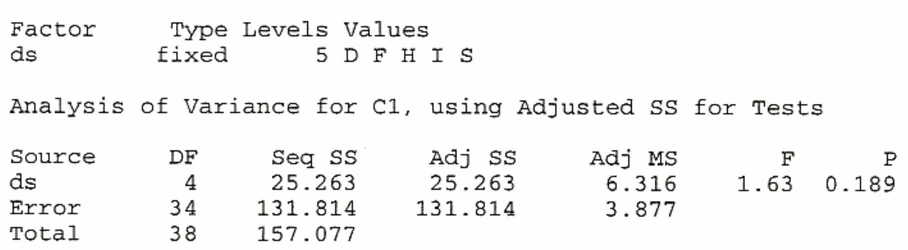


```
Factor     Type Levels Values
ds        fixed      5 D F H I S

Analysis of Variance for response, using Adjusted SS for Tests

Source      DF     Seq SS     Adj SS     Adj MS       F      P
ds           4     17.246     17.246      4.311    1.08  0.383
Error       34    135.985    135.985      4.000
Total       38    153.231
```

Table 5. The effect of Decision Style, HEC, and Recall

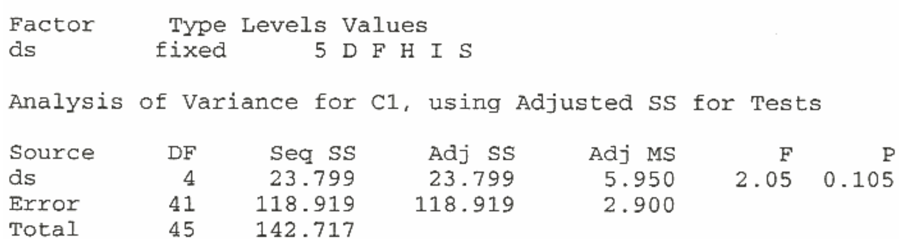


```
Factor      Type Levels Values
ds         fixed      5 D F H I S

Analysis of Variance for C1, using Adjusted SS for Tests

Source      DF      Seq SS     Adj SS      Adj MS        F       P
ds           4      25.263     25.263       6.316     1.63   0.189
Error       34     131.814    131.814       3.877
Total       38     157.077
```

Table 6. The effect of Decision Style, HEC, and Recognition



```
Factor      Type Levels Values
ds         fixed      5 D F H I S

Analysis of Variance for C1, using Adjusted SS for Tests

Source      DF      Seq SS     Adj SS      Adj MS        F       P
ds           4      23.799     23.799       5.950     2.05   0.105
Error       41     118.919    118.919       2.900
Total       45     142.717
```

Based on the calculated p-values, only the first effect of decision style is statistically significant, at an $\alpha = 0.05$. This indicates that there are differences in decision styles of our subjects considering the low environmental complexity and when it involves recalling information about the HRC intersection. One way of interpreting this result is that those who are, for example, decisive decision-makers, seem to recall the HRC environmental information differently. This also means that this difference becomes larger when the decisive decision-makers are faced with fewer signals and distracters while making a left-turn in a non-busy intersection.

None of the other conditions in our ANOVA resulted in significant differences among the DS categories. We believe that this was primarily due to the parametric nature of the test and also the low power of this test. In other words, with ten subjects in each cell the power of the statistical test was not sufficient to detect any significance. A much larger number of subjects (around 300) would have given us a better indication of these differences, when using a parametric regression test such as ANOVA. However, conducting an experiment with this many subjects would have required substantially larger resources, not available to the researchers here. So, we began developing a non-parametric test for our data.

Chi-Square Analysis

After the results of our ANOVA, we reorganized our data to conduct a non-parametric test. One such test is a chi-square test. This time, due to the low number of subjects, we grouped the decision style into two levels. Subjects were grouped into two (18-member) groups based on their decision style: single alternative (SI) or multiple alternative (MU). SI is a subject whose decision style test is Decisive, Hierarchical or Systemic and MU is a subject whose decision style is either Flexible or Integrative. Decision style research indicates that such dichotomy makes sense when the subjects are dealing with gathering and processing a large amount of information from objects in an environment.

The subjects decision style scores are given in Appendix B. The following table shows how the subjects are grouped according to their decision style versus two levels of TP and two levels of EC.

Table 7. Chi-Square Test Table (Time Pressure Vs. Env. Complexity)

	Decision style as Grouping Variable ⇓		
Nested System Variables ⇒		TP (H,L)	EC (H,L)
	Decisive + Flexible		
	Integrative + Hierarchical + Systemic		

Each system variable (independent variable) is nested with two levels of “high” and “low.” The variables are Time Pressure (TP) and Environmental Complexity (EC). The subjects are licensed drivers assigned to cells i (between-subject design) and j (within-subject design). The subjects will be randomly assigned to each cell to reduce learning effects. For each subject, we measured the aggregate number of signals and noise items that they identified in their respective scenes, as explained below.

A signal is an environmental object or item, which draws the attention to the possibility of a crossing train presence. On the other hand, a noise item is an environmental object, which takes away the attention of the subject from the possibility of a crossing train presence. The following table presents object’s type (noise/signal) in an intersection with environmental complexity. We have added a weighting factor to scale the importance of each item within the scene. Appendix C begins with an object identification key for each identifiable item in the intersection, then it shows the raw number of objects identified for each driver. The number of objects identified for each driver and its cross-tabulation for LEC and HEC, object recognition versus object recall, signal versus noise are shown in Appendix D. Appendix E contains the verbal comments by each subject during the experimental trials. In this appendix, the video clips used for experimental trials are also included.

Table 8. Environmental Complexity Objects and Their Assigned Weights

Objects	Noise/Signal	Weight
Pedestrians	N	1
Vehicles	N	1
General signs	N	1
Traffic direction	N	1
Vendors	N	1
Buildings	N	1
Number of lanes of through traffic	N	0.5/lane
Number of lanes of perpendicular traffic	N	0.5/lane
Signal poles	N	0.5
Trees	N	0.5/tree
Cross walk	N	1
Side walk	N	1
Train-related signs	S	2
Train station	S	2
Passing train	S	2
Train tracks	S	2

We, therefore, designed a 4x4 chi-square table in order to study the effects of each decision style on the HRC safety factors. In the chi-square table above, independent variables are grouped into decision styles and system variables.

The following tables show the chi-square test result for HEC and LEC environments. The data for the chi-squared test is from the raw count of signal and noise in the HR crossings (Appendix C). For each complexity level, the tables show both the actual signal and noise items versus the expected ones for LEC and HEC situations.

Table 9. The Results of Chi-Square Tests for LEC

Actual	Recall			Recognition		
	Signal	Noise	Total	Signal	Noise	Total
D+H+S	27	90	117	17	51	68
F+I	38	117	155	30	72	102
Total	65	207	272	47	123	170

Expected	Recall		Recognition	
	Signal	Noise	Signal	Noise
D+H+S	27.96	89.04	18.8	49.2
F+I	37.04	117.96	28.2	73.8

Chi square 0.782785022 0.528648

Table 10. The Results of Chi-Square Tests for HEC

Actual	Recall			Recognition		
	Signal	Noise	Total	Signal	Noise	Total
D+H+S	40	97	137	19	62	81
F+I	42	111	153	25	63	88
Total	82	208	290	44	125	169

Expected	Recall		Recognition	
	Signal	Noise	Signal	Noise
D+H+S	38.74	98.26	21.09	59.91
F+I	43.26	109.74	22.91	65.09

Chi square 0.742083 0.463346

The Chi-square results show no significance, based on a type I error of 0.05. In other words, there was no significant difference between the two groups of decision styles for each level of recall and recognition. The same applied to the signal items (i.e., train-related) versus noise items (i.e., environmental distracters). This lack of significance was seen in both low and high environmental complexity situations.

3. CONCLUSIONS AND RECOMMENDATIONS

In our previous research (e.g., Meshkati, et. al. 1999), we indicated that different decision styles have a different but predictable tolerance for, and response to, different task dimensions such as complexity, uncertainty and information load. It is expected that those decision styles which are categorized as multifocus (i.e., Integrative and Flexible) will have more options and perform better when responding to events containing high levels of uncertainty. In addition, those with information maximizing styles (i.e., Integrative, Hierarchic and Systemic) experience less strain (respond more smoothly) to high levels of complexity than those with information satisfying styles (i.e., Decisive and Flexible). This is particularly critical during events requiring unfamiliar reasoning and diagnosis where uncertainty and complexity are typically high. To illustrate this point, consider an individual who has a unifocus, information satisfying style (Decisive) that is required to contend with an unfamiliar grade crossing. This individual will experience a high degree of stress when attempting to analyze the situation. On the other hand, this kind of unfamiliar scenario is more comfortable for multifocus, information maximizers (i.e., Integrative), provided the time pressure was not excessive. That is, a routine situation requiring a quick decision would be best handled by Decisives (unifocus, information satisficers) as compared to those who are multifocus, information maximizers (i.e. Integrative).

Also, based on previous and this research, it is concluded that the drivers' individual decision styles and the combination of their styles play an important role in making decision concerning to cross or not to cross under different environmental conditions and time pressure situations. (For a detailed account of the subject's verbal responses during the experimental trials, see Appendix D). Finally, drivers' decision styles affect both their recall and recognition performance of grade crossing signage warming systems. The important implication of this research is that the grade crossing and warning light and signage design must take into consideration the different informational needs of drivers performing different types of driving tasks.

4. IMPLEMENTATION

In the scientifically oriented literature on HRC accidents, there are scant references to the root causes of these accidents, such as a disregard for stop signs, failure to look for trains, distraction, judgment error, inattention, fatigue, or drug impairments. In popular press, on the other hand, we often see these causes reduced to "human error." Should we be satisfied with this reductionism? Some argue that this is sufficient due to the success record of bringing this argument in the legal challenges against MTA. We argue that the precautions required by the legal and regulatory statutes are not sufficient to ensure safety in the Los Angeles HRC context. While this argument may be legally defensible, it is scientifically and morally questionable. The proportionally high rate of both fatal and nonfatal accidents should be a sufficient indication that the current procedures for designing and operating warning systems are not adequate.

The critical failure of current rail safety technical analysis is that it does not investigate how people with different information processing behavior and risk perception actually respond to light rail warning systems and protective safety features. An “average” person under normal conditions with maximum attentional resources may have no problem recognizing what warning signs are telling them. But someone who is under time pressure, distracted, has slower reflexes, or is unfamiliar with the location, will be less likely to notice and realize that s/he is in danger at the critical moments. The responsibility in these situations should not be placed entirely on the driver and the pedestrian because it is unrealistic to expect that individuals will always be in ideal cognitive circumstances when they come upon the warning signs. Warning features should be designed for the most at risk individuals, not just for the “average” individual.

The drivers and pedestrians in Southern California are especially vulnerable to this problem because light rail is new here. The population in general is not familiar with trains running across their streets and backyards, and they have not internalized the inherent risks associated with HRCs in their cognitive and behavioral characteristics. For example, whenever we are in the “left-turn only” lane of an intersection, we are used to be watchful of the oncoming traffic. Our risk perception domain is not sensitized to a situation that requires us to look into the side mirror searching for a potential vehicle passing us on the left side. Therefore, a driver at a rail crossing, attempting to turn left would have a higher chance of collision with a train approaching from behind, because the driver does not expect a vehicle coming from behind. Not surprising, statistics indicate a significantly higher collision rates for MTA trains by drivers attempting to make a left turn in violation of standard traffic signals correctly displayed at HRCs. In these cases, the drivers may have thought that they are risking a traffic ticket, but they are probably risking their lives without the intersection and its environment conveying the risk to the driver.

Despite their genuine interest in protecting public safety and dedicated safety staff, neither the MTA nor Metrolink have been successful at addressing the complex issue of grade crossing safety. Therefore, we recommend that the MTA and Metrolink begin a systematic investigation on how people react to warning signs, signals, symbols, and pedestrian protective systems, and how these designs are perceived and responded to by diverse groups of people under a variety of conditions and situations. The MTA’s $400,000 portable multimedia theater for public education and Metrolink’s 177 public presentations in 2002 may constitute necessary steps in the right direction, but they are far from being sufficient at preventing HRC accidents at this time. Presently neither the Federal Transit Administration nor the California Public Utilities Commission (CPUC), as the designated state safety oversight agency, have a readily available standard or a sensible guideline for taking into account the local population’s characteristics, limitations and capabilities in the design of warning signs and protective systems at grade crossings. The CPUC’s voluminous safety audit of the MTA in 2002 concentrated only on how the operation and maintenance of a few randomly chosen “crossing warning” systems and devices conformed with “(LAC)MTA signal maintenance standards.” The safety audit addressed neither the adequacy of design features of such systems and devices nor their critical human factors considerations that affect intended users behavior.

This is not the time for recriminations. We do need to spend resources on rail transportation infrastructure in the region; yet, its ultimate success depends on improved rail safety performance. To do this we need a paradigm shift in how we implement our light rail infrastructure. To paraphrase the American philosopher William James who once said, “Great emergencies and crises show us how much greater our vital resources are than we had supposed”. In order to stop and reverse the dangerous direction we are headed in the MTA, Metrolink, the California Transportation Commission, the CPUC, the Federal Transit Administration, the Federal Railroads Administration, and the research community must rise to the challenge. We need to work together to systematically analyze all the pervious accidents, to study all the existing crossings, and to come up with redesign of crossings and warning signs and signals based on sound technical and human factors considerations.

We believe that we have a serious and urgent safety problem at our nation’s grade crossings, and further research is needed to study and address this problem.

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APPENDIX A

Instructions for Participants

The investigators would like to thank you for participating in this research.

In this session, you will be watching four short video clips of traffic in downtown Los Angeles. After each clip, you will be asked to fill out a short questionnaire.

When you receive a signal from the investigator, the video clip begins running. While watching this video, please try to imagine yourself as a driver sitting in a driver seat of a car. Make sure that you watch the scene very carefully. We want you to concentrate on the video monitor while the clip is running in its entirety.

The investigator will hand you the questionnaire immediately after each clip. Your task is complete after responding to the questionnaire for the fourth video clip.

Please ***do not*** *share any information about this experiment and what you saw in the video clips with any other person. Others may be participants in this experiment, and we want them to be unbiased and "fresh" concerning any aspect of this study.*

Thank you!

Please write last 4 digit of your SS#___________________

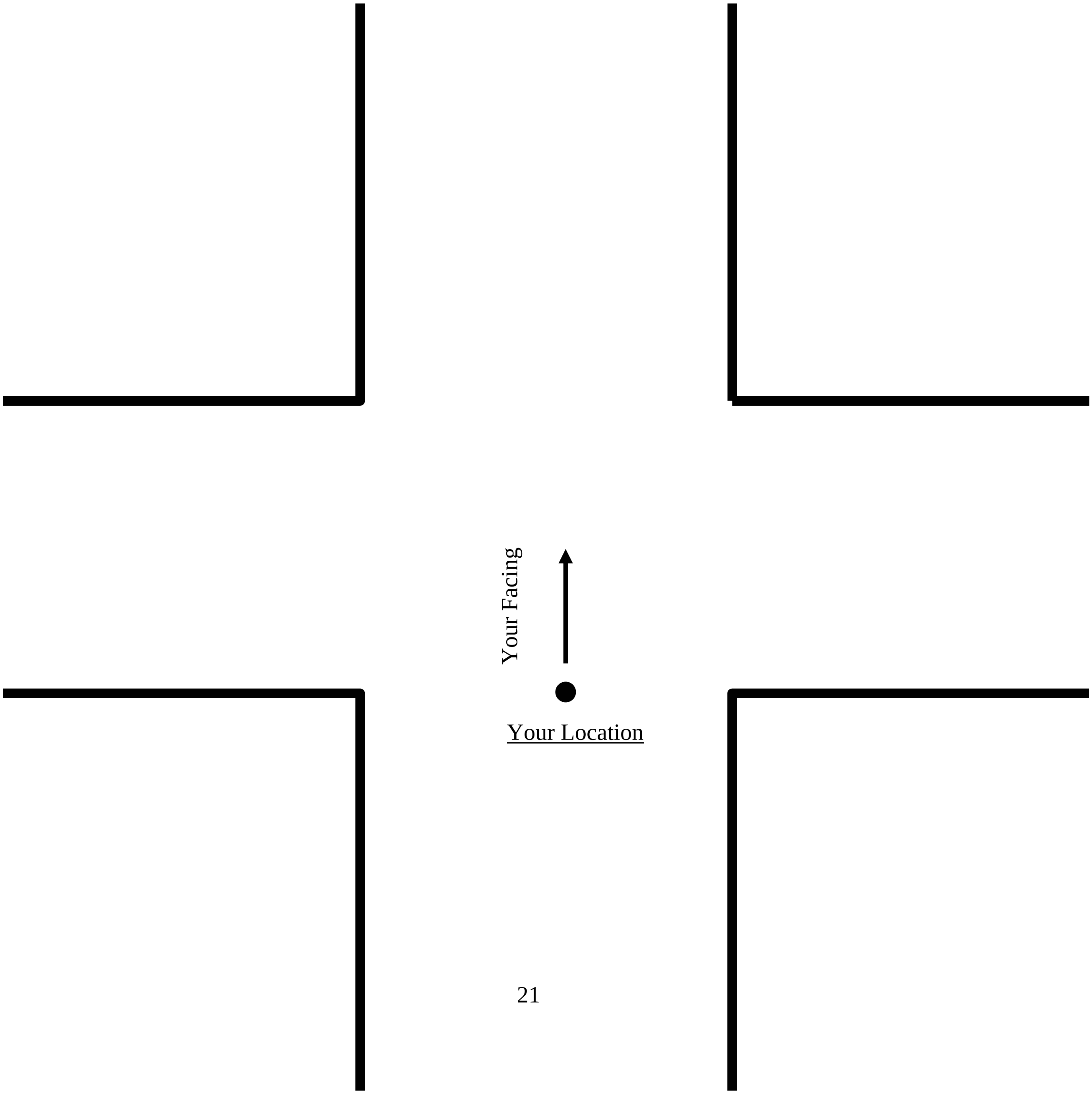
Post Video Survey HEC

Do you want to cross the intersection or make a left turn?

You are asked to answer the following questions:

Visualize the scene at the intersection. Draw and label <u>everything</u> that you remember in this clip. A simple sketch is provided below to help you identify the location of items you want to identify.

There is <u>no time pressure</u>, but please finish this drawing in less than five minutes.



Visualize the scene at the intersection. A simple sketch is provided below to help you identify the location of items. Draw and label <u>everything</u> that you remember in this clip. You may add, draw and label <u>anything</u> that is missed from the sketch.

There is <u>no time pressure</u>, but please finish it in about 5 minutes.

Which piece or pieces of information did you use when making your decision to cross the intersection or turn left or stay for the next light?

Was there any railroad track visible?

Was there any sign or signal to draw your attention to the presence of the railroad track?

Were there any signs or signals at the scene, other than railroad related?
If so, please name the sign(s) or signal(s):

What does each of the above signs or signals mean to you?

While waiting, what were you looking at? Please mention everything that you were looking at.

Which signs are meant for you when you are waiting to cross the intersection or make a left turn?

Were you familiar with this intersection prior to today's viewing?

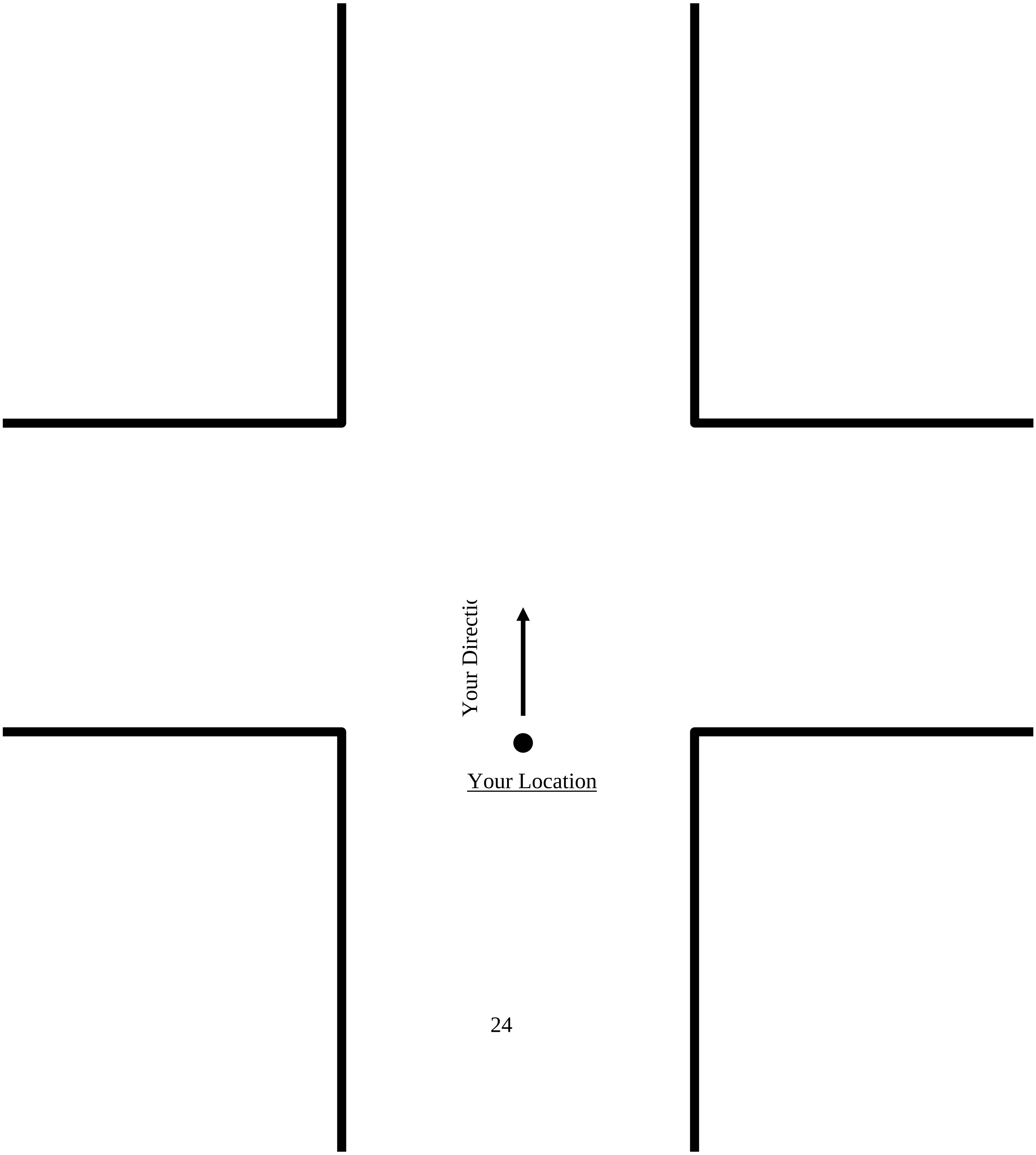
As you were making a left turn, was there anything you would like to see?

PLEASE WRITE DOWN LAST 4 DIGIT OF YOUR SS#____________________

Post Video Survey HTP

Would you have crossed the intersection or made the left turn here?

Empty intersection for memory recall
Visualize and draw the signs and traffic lights you saw in the scene.



Visualize the scene at the intersection. A simple sketch is provided below to help you identify the location of items. Draw and label __everything__ that you remember in this clip. You may add, draw and label __anything__ that is missed from the sketch.

There is __no time pressure__, but please finish it in about 5 minutes.

Which piece or pieces of information did you use when making your decision to cross the intersection or turn left or stay for the next light?

Was there any railroad track visible?

Was there any sign or signal to draw your attention to the presence of the railroad track?

Were there any signs or signals at the scene, other than railroad related?
If so, please name the sign(s) or signal(s):

What does each of the above signs or signals mean to you?

While waiting, what were you looking at? Please mention everything that you were looking at.

Which signs are meant for you when you are waiting to cross the intersection or make a left turn?

Were you familiar with this intersection prior to today's viewing?

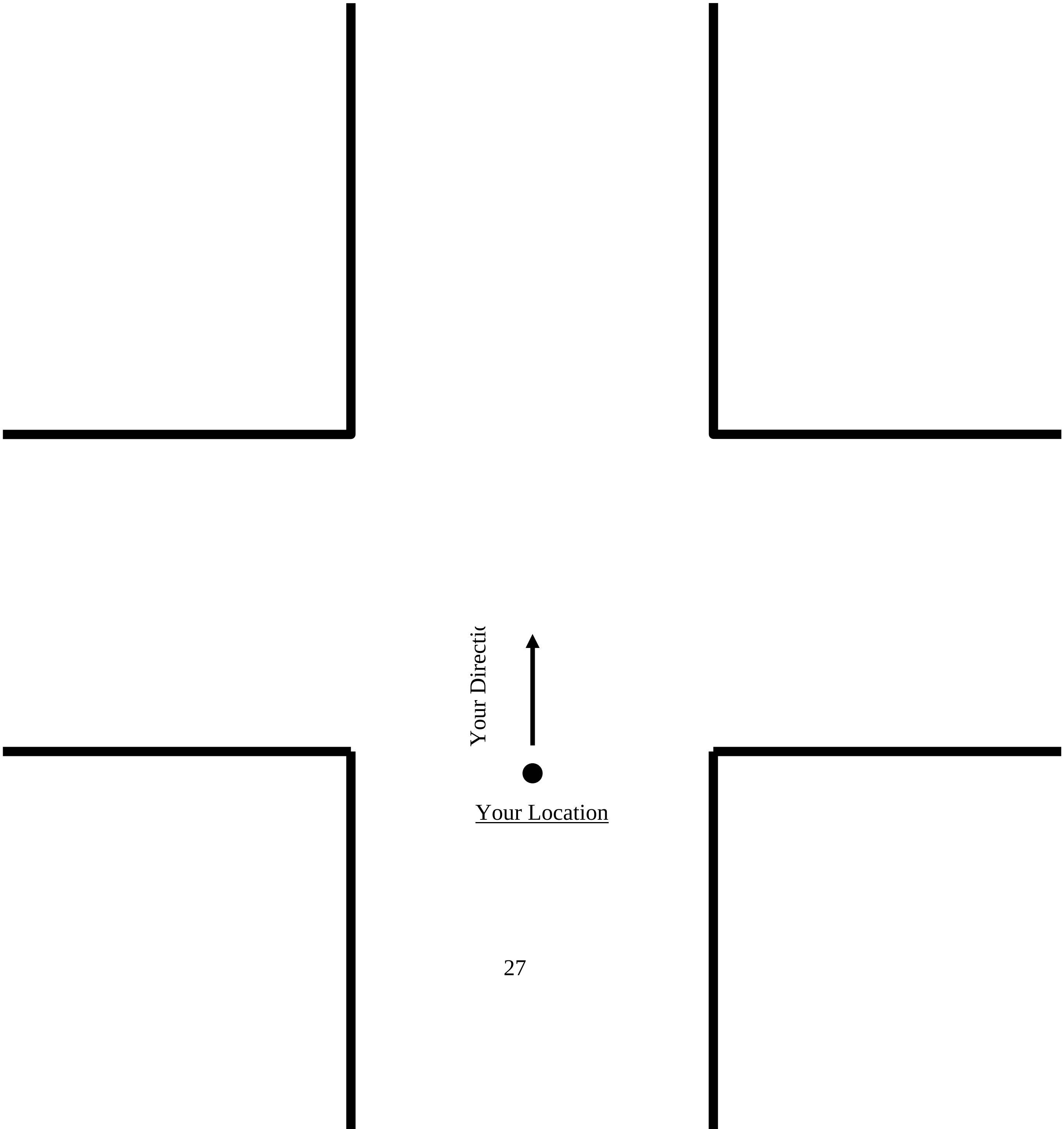
Please write down last 4 digit of your SS#__________________

Post Video Survey LEC

Do you want to cross the intersection or make a left turn?

You are asked to answer the following questions:
Visualize the scene at the intersection. Draw and label <u>everything</u> that you remember in this clip. A simple sketch is provided below to help you identify the location of items you want to identify.

There is <u>no time pressure</u>, but please finish this drawing in less than five minutes.



Visualize the scene at the intersection. A simple sketch is provided below to help you identify the location of items. Draw and label <u>everything</u> that you remember in this clip. You may add, draw and label <u>anything</u> that is missed from the sketch.

There is <u>no time pressure</u>, but please finish it in about 5 minutes.

Which piece or pieces of information did you use when making your decision to cross the intersection or turn left or stay for the next light?

Was there any railroad track visible?

Was there any sign or signal to draw your attention to the presence of the railroad track?

Were there any signs or signals at the scene, other than railroad related?
If so, please name the sign(s) or signal(s):

What does each of the above signs or signals mean to you?

While waiting, what were you looking at? Please mention everything that you were looking at.

Which signs are meant for you when you are waiting to cross the intersection or make a left turn?

Were you familiar with this intersection prior to today’s viewing?

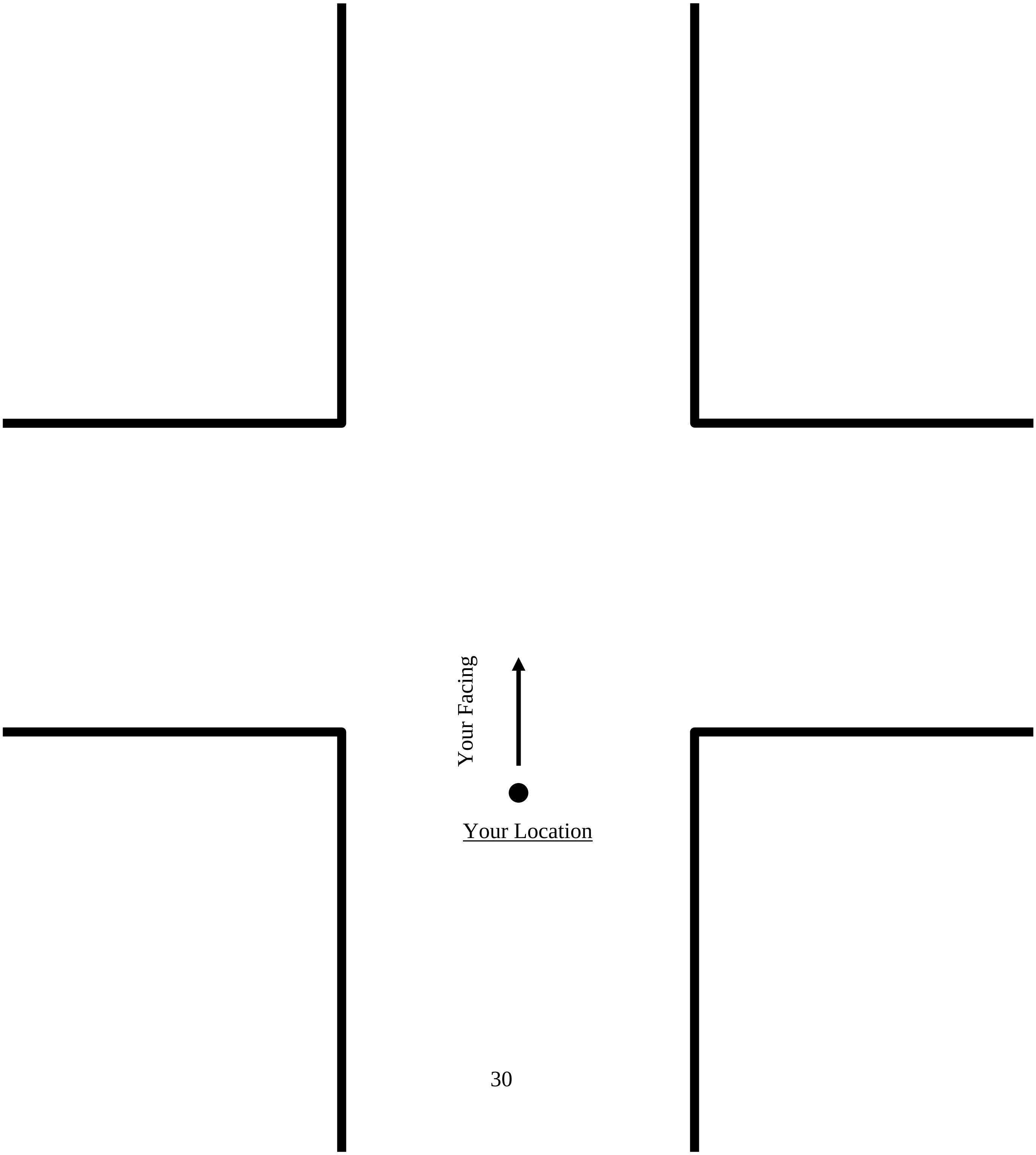
As you were making a left turn, was there anything you would like to see?

Please write down last 4 digit of your SS#___________________

Post Video Survey LTP

Would you have crossed the intersection or made the left turn here?

Visualize and draw the signs and traffic lights you saw in the scene.



Visualize the scene at the intersection. A simple sketch is provided below to help you identify the location of items. Draw and label <u>everything</u> that you remember in this clip. You may add, draw and label <u>anything</u> that is missed from the sketch.

There is <u>no time pressure</u>, but please finish it in about 5 minutes.

Which piece or pieces of information did you use when making your decision to cross the intersection or turn left or stay for the next light?

Was there any railroad track visible?

Was there any sign or signal to draw your attention to the presence of the railroad track?

Were there any signs or signals at the scene, other than railroad related?
If so, please name the sign(s) or signal(s):

What does each of the above signs or signals mean to you?

Which signs are meant for you when you are waiting to cross the intersection or make a left turn?

Were you familiar with this intersection prior to today's viewing?

APPENDIX B

Decision Styles of the Drivers Participating in the Experiment (N=43)

ID NUMBER	H OP	I OP	F OP	D OP	S OP	PRIM OP	BACK OP	H LEVEL	I LEVEL	F LEVEL	D LEVEL	S LEVEL
8,337	47.75	29.90	14.76	34.12		H	I	MH	M	L	L	
6,044	42.95	27.30	44.50	16.58		F	H	MH	ML	MH	VL	
3,599	45.10	44.10	39.50	13.60	44.60	S	F	MH	MH	MH	VL	MH
9,837	37.30	16.80	44.50	21.97		F	H	M	L	MH	L	
2,714	32.00	30.20	9.52	42.60	31.10	S	D	M	M	L	ML	M
6,185	13.35	26.20	49.50	23.48		F	I	L	ML	H	L	
2,899	18.85	21.85	9.52	49.77		D	I	L	ML	L	MH	
2,835	20.30	20.00	9.52	49.90	20.15	D	S	ML	L	L	MH	ML
4,827	12.90	24.60	44.50	27.50		F	I	L	ML	MH	L	
5,523	16.20	18.65	20.00	45.05		D	F	L	L	L	MH	
2,109	26.80	17.55	29.50	35.22		D	F	ML	L	M	M	
3,465	29.75	48.60	64.50	0.55		F	I	M	MH	VH	VL	
9,307	40.15	32.40	20.00	32.48	36.28	S	D	MH	M	L	L	M
5,295	20.00	51.80	64.50	2.73		F	I	L	H	VH	VL	
1,833	43.60	21.65	14.76	38.25		H	I	MH	ML	L	L	
2,910	26.10	17.55	34.50	32.12		F	H	ML	L	M	L	
2,285	21.60	34.00	49.50	18.13		F	I	ML	M	H	VL	
2,129	20.05	22.45	34.50	32.50	21.25	F	S	ML	ML	M	L	ML
4,887	29.50	39.90	14.76	36.87		I	H	M	MH	L	L	
9,079	43.65	41.65	-	38.23	42.65	S	D	MH	MH	VL	L	MH
8,464	32.40	18.90	9.52	46.23		H	D	M	L	L	ML	

9,392	21.25	17.80	34.50	33.65		F	H	ML	L	M	L	
1,021	45.90	23.00	24.74	30.37		H	F	MH	ML	ML	L	
2,602	19.80	46.00	20.00	34.73		I	D	L	MH	L	L	
1,416	18.00	25.70	54.50	18.77		F	I	L	ML	H	VL	
2,966	46.20	67.25	49.50	(1.15)		I	F	MH	VH	H	VL	
8,763	8.40	3.30	24.74	49.43		D	F	VL	VL	ML	MH	
1,369	16.65	16.10	49.50	25.75		F	D	L	L	H	L	
3,750	70.15	91.90	49.50	(17.35)		I	H	VH	VH	H	VL	
4,850	36.00	108.00	54.50	(14.67)		I	F	M	VH	H	VL	
4,924	34.45	14.80	14.76	43.58		H	D	M	L	L	ML	
5,004	26.70	31.35	14.76	40.65		I	H	ML	M	L	ML	
6,675	47.40	33.60	39.50	16.33		H	F	MH	M	MH	VL	
9,253	25.40	46.35	59.50	6.08		F	I	ML	MH	VH	VL	
2,575	34.00	59.40	9.52	32.20		I	H	M	VH	L	L	
2,669	15.20	16.00	54.50	22.93		F	D	L	L	H	L	
5,731	35.95	43.20	20.00	30.28	39.58	S	D	M	MH	L	L	MH
2,379	52.85	9.85	24.74	32.43		H	F	H	L	ML	L	
2,569	28.95	84.70	14.76	22.12		I	H	ML	VH	L	L	
2,330	21.70	27.00	14.76	43.77	24.35	D	S	ML	ML	L	M	ML
5,542	27.90	45.50	(10.00)	45.53		I	H	ML	MH	VL	ML	

APPENDIX C

Object Identification Key for each Identifiable Item in the Intersection, Decision Style Types versus Objects Identified in the Environment

key

frequency is counted if the subject records the following listed items

NOTE: objects are only counted once. There is only one count whether the subject annotated one car or many cars

pedestrians - are recorded if they were scetched or
cars - cars and buses
general signs - street lights and street signs
traffic direction - recorded if a direction arrow was annotated to show direction of traffic
vendors - street vendors
buildings/billboards - buildings and billboards
lanes of through traffic - recorded when the subject split the road into lanes
lanes of perpendicular traffic- recorded when the subject split the road into lanes
signal poles - labeled when the subject drew a pole holding the signals
cross walk - cross walk
side walk - sidewalk
train-related signals - street signs warning of train tracks and the yellow suspended sign which blinked when train passed
train station - shelter next to the train tracks
passing train - tram, trolley, train, all recorded as passing train
train tracks - train tracks
rail car lines - refers to the power cables which run over the train parallel to the train tracks

	Decisive							
	LEC		HEC		LTP		HTP	
	recall	recognition	recall	recognition	recall	recognition	recall	recognition
pedestrians								
cars	3		2		3	1	4	
general signs	5	5	5	5	5	5	5	4
traffic direction			1					
vendors								
buildings					1		1	
lanes of through traffic	1				1			
lanes of perpendicular traffic	1				1			
signal poles	1	3	1	2		2		1
cross walk		1					1	
side walk								
train-related signals	3	3	4	4	1		2	
train station								
passing train	1		2					

train tracks	3	1	3	1	1		1	
rail car lines		1						

Flexible

	LEC		HEC		LTP		HTP	
	recall	recognition	recall	recognition	recall	recognition	recall	recognition
pedestrians	1	1	3	3	1	1		2
cars	8	6	5	3	8	4	10	9
general signs	13	12	12	12	12	13	13	11
traffic direction	1		1		1	1		1
vendors								
buildings	3	1	4	2	2	2	4	2
lanes of through traffic	4		4		2		2	1
lanes of perpendicular traffic	3		3		1		2	
signal poles	6	7	7	10	7	7	9	6
cross walk	2		4	2	4	1	4	1
side walk	1	1	2		1		1	
train-related signals	9	6	8	7	1	1		
train station	1		1	1				
passing train	8	5	8	7				
train tracks	11	5	12	6	2	2	1	1
rail car lines	1							

Hierarchal

	LEC		HEC		LTP		HTP	
	recall	recognition	recall	recognition	recall	recognition	recall	recognition
pedestrians			1	1			1	
cars	3		3		2		6	2
general signs	7	6	7	7	7	4	7	7
traffic direction	1				1	2	1	1
vendors								
buildings	1	1	1	1	3	2	2	2
lanes of through traffic	1		1		1		1	
lanes of perpendicular traffic	1				1		1	
signal poles	2	2	3	4	3	3	2	2
cross walk								
side walk								
train-related signals	3	2	4	5	1		1	
train station								
passing train	2	2	4	2				
train tracks	5	1	6	2				
rail car lines	1	1						

Integrative

	LEC		HEC		LTP		HTP	
	recall	recognition	recall	recognition	recall	recognition	recall	recognition
pedestrians			1	1				
cars	2		2	1	2	1	3	4
general signs	7	8	7	8	8	8	8	8
traffic direction								
vendors								
buildings			1			2	2	3
lanes of through traffic			2					
lanes of perpendicular traffic								
signal poles	1	3		3		5		3
cross walk								
side walk								
train-related signals	6	7	3	4			2	1
train station			1	1				
passing train	1	2	4	1				
train tracks	6	2	6	1		1	3	1
rail car lines								

Systemic

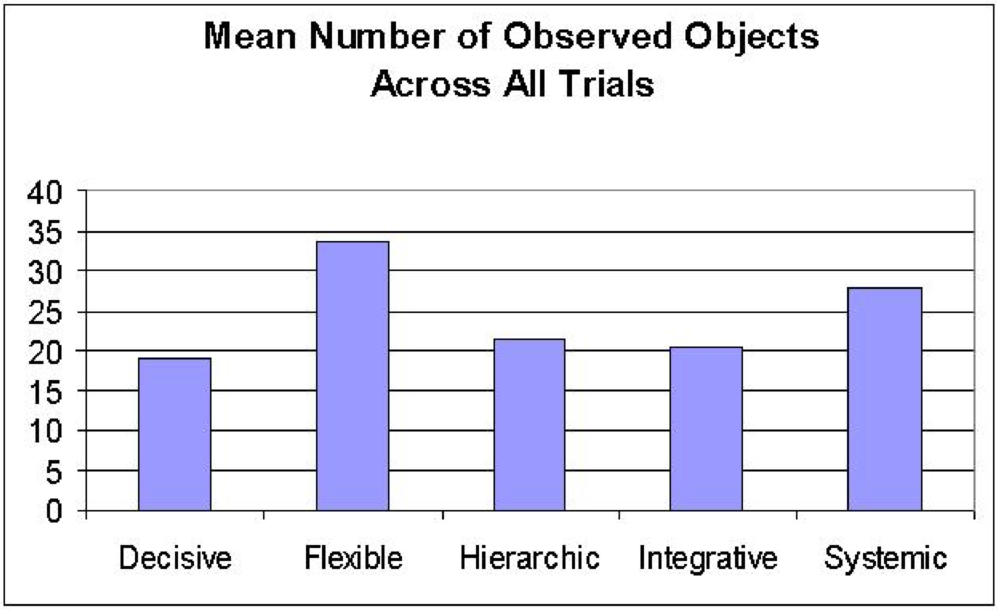
	LEC		HEC		LTP		HTP	
	recall	recognition	recall	recognition	recall	recognition	recall	recognition
pedestrians	1		1	1				
cars	2	3	1	2	2		2	2
general signs	4	5	4	4	5	4	5	4
traffic direction								
vendors								
buildings			1	2			1	
lanes of through traffic			2				1	
lanes of perpendicular traffic	1		2	1	1			
signal poles	1	2	1	2		2	2	1
cross walk	1		1		1			
side walk								
train-related signals	3	2	3	2				
train station			1					
passing train		2	1	1				
train tracks	5	1	5	1	1	1	1	1
rail car lines								

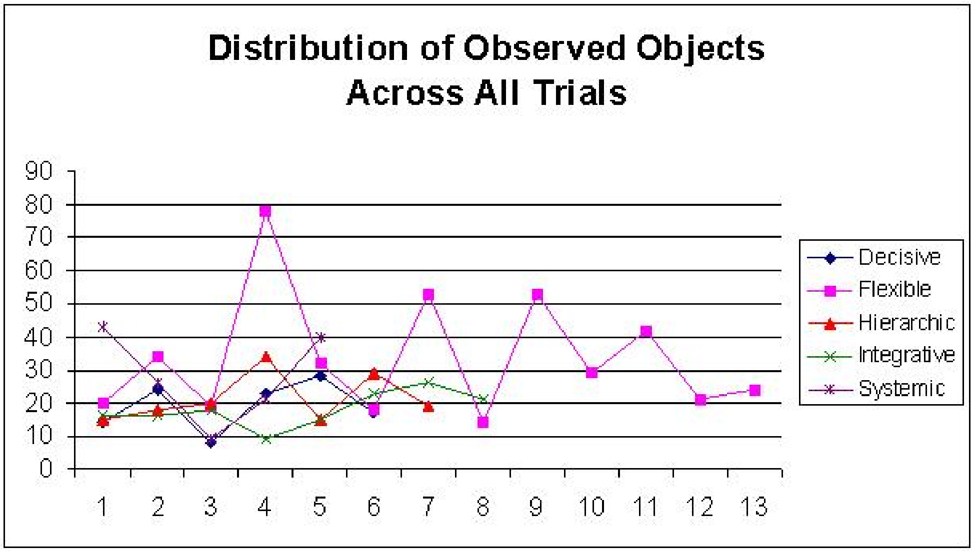
APPENDIX D

The Number of Objects Identified by each Subject for Two Environmental Complexity Categories, Two Information Identification Types, and Signal versus Noise

		LEC						HEC					
		recall			**recognition**			**recall**			**recognition**		
		items	signal	noise	items	signal	noise	items	signal	noise	items	signal	noise
8702	**D**	5	3	2	0	0	0	9	3	6	0	0	0
2109	**D**	8	2	6	7	3	4	5	2	3	4	1	3
2899	**D**	0	0	0	3	0	3	0	0	0	5	1	4
5523	**D**	11	1	10	3	1	2	5	4	1	4	1	3
2835	**D**	12	1	11	4	0	4	7	2	5	5	1	4
1580	**D**	4	2	2	3	1	2	5	2	3	5	1	4
2379	**H**	3	1	2	2	0	2	6	2	4	4	1	3
2491	**H**	4	1	3	4	1	3	5	1	4	5	1	4
183	**H**	7	2	5	4	2	2	5	2	3	4	1	3
8464	**H**	9	1	8	12	2	10	7	1	6	6	1	5
1021	**H**	4	1	3	1	0	1	4	1	3	6	0	6
8337	**H**	5	0	5	3	0	3	15	2	13	6	2	4
4924	**H**	8	2	6	1	1	0	7	5	2	3	1	2
2714	**S**	16	1	15	6	1	5	13	3	10	8	1	7
9079	**S**	7	3	4	6	2	4	7	3	4	6	1	5
3599	**S**	1	1	0	2	1	1	4	1	3	2	2	0
9307	**S**	6	4	2	4	1	3	8	4	4	3	1	2
5731	**S**	7	1	6	3	1	2	25	2	23	5	2	3
6044	**F**	7	4	3	4	1	3	6	3	3	3	1	2
1369	**F**	15	2	13	5	1	4	8	2	6	6	1	5
9392	**F**	5	1	4	4	0	4	6	1	5	4	1	3
4827	**F**	26	2	24	15	1	14	25	3	22	12	4	8
228	**F**	9	3	6	6	2	4	9	2	7	8	2	6
5295	**F**	5	2	3	4	1	3	6	3	3	3	2	1
2129	**F**	16	4	12	14	4	10	12	4	8	11	4	7
2910	**F**	3	0	3	2	0	2	6	2	4	3	0	3
1416	**F**	21	3	18	9	3	6	15	3	12	8	2	6
2669	**F**	8	3	5	9	7	2	6	3	3	6	1	5
6185	**F**	12	4	8	8	2	6	12	3	9	10	3	7
9837	**F**	4	1	3	5	1	4	6	2	4	6	2	4

9253	**F**	12	4	8	0	0	0	12	3	9	0	0	0
4850	**I**	6	1	5	3	0	3	5	2	3	2	0	2
3750	**I**	5	2	3	4	1	3	4	1	3	3	1	2
2569	**I**	5	1	4	3	1	2	7	3	4	3	1	2
2966	**I**	1	0	1	4	3	1	3	0	3	1	0	1
5004	**I**	4	2	2	4	2	2	6	1	5	1	0	1
2575	**I**	5	2	3	6	2	4	4	2	2	8	4	4
5542	**I**	5	2	3	4	1	3	10	3	7	7	1	6
2602	**I**	6	1	5	4	1	3	7	3	4	4	1	3




Distribution of Observed Objects
Across All Trials
90
80
70
60
50
40
30
20
10
0
1
2
3
4
5
6
7
8
9
10
11
12
13
Decisive
Flexible
Hierarchic
Integrative
Systemic

APPENDIX E

1. Subject's Verbal Responses Recorded and Tabulated During the Four Experimental Conditions in .xls format (to open this file, you need this file and the final report in the same sub-directory; for a print version see the next pages)

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2. Four Video Clips, One for Each Experimental Condition (in video .rm format)

High Env Complexity.RM

HighTimePressure.rm

Low Env Complexity.RM

LOWTimePressure.rm