DEPARTMENT OF TRANSPORTATION

Establishing a Repeatable Method for Presenting Non-Traditional Traffic Treatments to Maximize Stakeholder Support

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AUGUST 2023

Research Project
Final Report 2022-31

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Technical Report Documentation Page

1. Report No.	2.	3. Recipients Accession No.
MN 2022-31		

4. Title and Subtitle	5. Report Date
Establishing a Repeatable Method for Presenting Nontraditional Traffic Treatments to Maximize Stakeholder Support	August 2023
	6.

7. Author(s)	8. Performing Organization Report No.
Morris, N.L., Schwieters, K.S., Craig, C.M., & Tian, D.	

9. Performing Organization Name and Address	10. Project/Task/Work Unit No.
HumanFIRST Laboratory Department of Mechanical Engineering University of Minnesota 111 Church St. SE, Minneapolis, MN 55116	CTS #2020001
	11. Contract (C) or Grant (G) No. (c) 1003325 (wo) 98

12. Sponsoring Organization Name and Address	13. Type of Report and Period Covered
Minnesota Department of Transportation Office of Research & Innovation 395 John Ireland Boulevard, MS 330 St. Paul, Minnesota 55155-1899	Final Report
	14. Sponsoring Agency Code

15. Supplementary Notes
http://mdl.mndot.gov/

16. Abstract (Limit: 250 words)
A novel infrastructure design known as the J-turn intersection reduces the risk of serious and fatal crashes at thru-STOP intersections through decreasing points of conflict at an intersection by restricting crossing movements from the minor road. Despite their demonstrated safety efficacy, J-turns have not been met with uniformly positive support. In this research, we first examine novice driver baseline attitudes and driving behaviors on J-turns using a driving simulator study. Results demonstrate that critical errors are decreased with driving exposure to the J-turn; however, attitudes toward J-turns are not improved by exposure alone. A series of studies then evaluates the efficacy of various messaging strategies and educational materials on improving attitudes toward J-turns. The findings from these studies identify that the use of both educational materials and persuasive and customized messaging strategies is an effective method for increasing acceptance of J-turns across diverse resident populations (i.e., rural, suburban, and urban) and among stakeholders in Minnesota. This work demonstrates the importance of the role of proactive educational programs and community initiatives in promoting the acceptance and buy-in toward novel roadway treatments, such as J-turns, among diverse drivers, communities, and stakeholder groups.

17. Document Analysis/Descriptors	18. Availability Statement
Intersections, Rural highways, Drivers, Behavior, Public participation, Simulation, Education, Outreach	No restrictions. Document available from: National Technical Information Services, Alexandria, Virginia 22312

19. Security Class (this report)	20. Security Class (this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	112	

ESTABLISHING A REPEATABLE METHOD FOR PRESENTING NONTRADITIONAL TRAFFIC TREATMENTS TO MAXIMIZE STAKEHOLDER SUPPORT

FINAL REPORT

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August 2023

Published by:

Minnesota Department of Transportation
Office of Research & Innovation
395 John Ireland Boulevard, MS 330
St. Paul, Minnesota 55155-1899

ACKNOWLEDGMENTS

The authors would like to thank the Minnesota Local Road Research Board and the Minnesota Department of Transportation for funding this project and specifically Scott Thompson, P.E., Derek Leuer, P.E., and David Glyer for their support and guidance. Special thank you to the members of the Technical Advisory Panel and other important contributors including Chris Chromy, P.E., PTOE, Shannon Fiecke, Charles Ombati, Elizabeth Klemman, Nick Klisch, Brett Paasch, Tim Stahl, Anne Wolff, Stephen Schnieder, Max Gagnon, Morrie Lukejoe, James Miles, Pippi Mayfield, and Nighthawk Marketing.

Thank you to the HumanFIRST research team, Peter Easterlund, Jacob Achtemeier, Marshall Mabry, Zhenming Xie, Weiqi Chen, Frank Koenen, Peroushini Villamma, Kshitij Suresh Sonkar, Savindie Liyanagamage, and McKenzie Shepard. The amount of hard work and dedication they put into collecting this data was integral to the project's success. A heartfelt thank you to the Minnesotans who shared their experiences about J-turns including Laurie Green and Robert Wagner, Minnesota's Largest Candy Store, Jordan, Minnesota; Ryan Stern, Jordan Supper Club, Jordan, Minnesota; Art Benson, Willmar, Minnesota; Todd Prafke, city administrator, St. Peter, Minnesota; James Erwin, Alumacraft Boats, St. Peter, Minnesota; Nathan Hite, Minneapolis, Minnesota; and Trooper Joe Dellwo, Minnesota State Patrol. Finally, thank you to the participants across the state who participated in this research. Without their time and engagement, this research would not have been possible.

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LIST OF ABBREVIATIONS

CI: Confidence Interval

J-turn: J-turn intersection - See also RCI and RCUT

M: Mean

RCI: Reduced Conflict Intersection - See also J-turn and RCUT

RCUT: Restricted Crossing U-Turn (intersection) - See also RCI and J-turn

SD: Standard Deviation

EXECUTIVE SUMMARY

Rural thru-STOP intersections consistently experience high rates of serious injury and fatal crashes in Minnesota (Preston & Storm, 2003; 2004). One possible design to reduce the risks of serious injury and fatal crashes is a J-turn intersection J-turns, (sometimes referred to as restricted crossing U-turn intersections or RCUTs, reduced conflict intersection or RCIs, or superstreet intersections) require drivers to make a right turn and then a U-turn to complete a left turn. However, their implementation is often met with resistance from stakeholders and community members where J-turns are to be implemented. Thus, the goal of this work is to develop clear and reproducible methods for engaging community members and stakeholders related to J-turns and other nontraditional traffic treatments to increase buy-in and public acceptance of nontraditional traffic treatments.

To develop a compelling set of persuasion tools, a review of the scientific literature on effective messaging strategies is completed to guide the ensuing study designs and select survey metrics with the greatest chance of capturing how various messaging strategies influence decision-making and attitudes. Persuasion is understood as any change in attitude that results from exposure to a communication message (Petty & Cacioppo, 1986). One way to communicate a persuasive message is through narratives, such as testimonials. Communication messages delivered through testimonials are a powerful persuasive tool because they capture attention, evoke emotion, and entrance listeners in a manner that reduces resistance to the message (Krause & Rucker, 2020). Several factors can influence decision-making and attitudes, such as whether the speaker is perceived to be likable and trustworthy, the strength of the message argument, and the degree to which the story feels personally relevant (Chaiken & Eagly, 1983; Andreoli & Worchel, 1978; Petty et al., 1981; Cacioppo et al.,1983).

Next, we used a driving simulator study to examine novice driver baseline attitudes and driving behaviors on J-turns to determine whether attitudes toward J-turns could be improved through experience alone (i.e., without additional educational materials or messaging strategies). An additional aim was to examine driving performance and error prevalence at J-turns and determine to what extent, if any, the level of signage influenced performance. The results found common errors including failure to make the U-turn, late turns into the deceleration lane, and failure to merge into the correct lane following the U-turn. The level of signage had little effect on driving performance; however, some segment-specific driver speeds and self-reported workload measures (not statistically significant) suggested a moderate level of signage could potentially outperform the minimum or full signage condition. Overall, driving performance improved with repeated J-turn exposure, particularly in that drivers were less likely to make critical errors (such as missing the U-turn) during the subsequent simulated drives compared to their first-time exposure to a J-turn. However, simulated driving experience on J-turns was not powerful enough to improve attitudes toward J-turns. Thus, educational programs and other community initiatives should be available to better inform both novice and experienced drivers about J-turns, including the benefits of J-turns as well as personal stories (i.e., testimonials) from those who have previously experienced J-turns.

As such, a series of studies evaluated the efficacy of various messaging strategies and educational materials on improving attitudes toward J-turns. An initial study at the Minnesota State Fair tested the influence of different messaging modalities (i.e., educational materials, testimonial videos) on attitudes toward J-turns. The findings suggested that while other messaging techniques positively influenced attitudes toward J-turns, the use of testimonials (i.e., narrative storytelling) was particularly effective for multiple target audiences. A follow-up study analyzed the effectiveness of different types of testimonials on different audience demographics and showed that the persuasiveness of testimonial videos varied by geographic location. Specifically, the cues that viewers paid attention to in the testimonial videos (e.g., speaker credibility) influenced their attitudes toward J-turns. To further understand geographic differences on various messaging strategies and attitude change, a final study partially replicating the State Fair study was completed online to assess how well different persuasive messaging strategies resonated with viewers in communities that were likely to see J-turns implemented in the future (i.e., rural populations). The findings from these three studies identified that the use of both educational materials and customized messaging strategies was an effective method for increasing acceptance of J-turns across diverse resident populations in the state.

After establishing a set of educational materials and effective messaging strategies that improve attitudes toward J-turns in the State Fair, Testimonial, and Large Sample studies, the educational and messaging materials were packaged into a short online presentation to assess their effectiveness in securing J-TURN stakeholder support and the ability to improve confidence in communicating with their constituents about upcoming roadway treatments. The presentation materials presented to stakeholders satisfied the majority of needs and wants of stakeholders and suggested that they may be necessary to customize the content based on the unique needs of the community, (e.g., farm activities, pedestrian concerns). Furthermore, stakeholders expressed concern with their ability to adequately communicate with their constituents in a timely manner, suggesting a need for greater communication efforts to ensure information is conveyed to communities in advance of future roadway implementation projects.

To expedite communication processes with community members in locations within the state scheduled for upcoming roadway projects, the packaged presentation materials were presented at a virtual community engagement demonstration in Two Harbors, Minnesota. Because previous studies provided evidence of the importance of understanding the characteristics of the audience (e.g., geographic location), a slide deck using mixed-methods messaging strategies was presented in an online webinar on Highway 61 intersection improvements in collaboration with MnDOT personnel. The consideration of audience characteristics in the customization of educational and informational messaging strategies was an effective method for increasing acceptance and buy-in for novel roadway designs.

The findings from this work demonstrate the importance of the role of proactive educational programs and community initiatives in promoting the acceptance and buy-in toward novel roadway treatments, such as J-turns, for both novice and experienced drivers and across varying geographic locations in the state (i.e., urban, suburban, and rural areas). There are several recommendations to maximize the effectiveness of mixed messaging strategies to communicate upcoming novel roadway treatments across the state. Some core steps of persuasive messages and signage for J-turns include: 1) using a

mixed-methods communication strategy, which includes both testimonial and educational materials, 2) finding ways to get people to become personally involved prior to presenting educational information, 3) using shorter persuasive messages for less-invested individuals, 4) lead the persuasive message with information about the benefits, 5) when considering time constraints, keep testimonials in the presentation content, 6) use credible messengers when creating testimonials, and 7) understand that audiences can differ and have different dispositions toward J-turns.

CHAPTER 1: INTRODUCTION

1.1 RESEARCH OBJECTIVES

The goal of this work was to develop clear and reproducible methods for engaging community members and stakeholders related to J-turns and other nontraditional and relatively novel traffic treatments to increase buy-in and public acceptance of nontraditional traffic treatments. The engagement method could either be the J-turn itself and how it was designed and signed, or in another medium such as a brochure or testimonial.

1.2 RESEARCH PROBLEM AND BACKGROUND LITERATURE

Rural thru-STOP intersections consistently experience high rates of serious injury and fatal crashes in Minnesota (Preston & Storm, 2003; 2004). One novel infrastructure approach to mitigate unsafe driver exposure is the J-turn intersection (Bared, 2009), which decreases potential points of conflict by restricting crossings and reduces crashes by 28-44% (Inman & Haas, 2012). J-turn intersections are designed to target yield- or stop-controlled intersections or signalized intersections on four-lane, divided highways. J-turns require drivers to make a right turn and then a U-turn to complete a left-turn. J-turns reduce overall crash rates at intersections and severe right-turn angle crashes.

Although J-turns increase travel time by approximately one minute compared to traditional intersections, J-turns have been shown to greatly reduce overall crash rates and reduce the number of injury-related and fatal crashes (Inman et al., 2013; Edara et al., 2015). Additionally, careful attention must be given to design considerations of reduced conflict intersections. For example, when J-turns have traffic volume ranging between 1605 pc/h/ln to 1708 pc/h/ln or speeds over 40mph, signage should be posted to get drivers to slow down (Olarte et al., 2011). Similarly, a driving simulator study testing the efficacy of lane configuration and U-turn spacing indicated that J-turns with acceleration plus deceleration lanes and U-turns with longer spacing resulted in 66.3% fewer safety critical events (Sun et al., 2017).

While J-turns have demonstrated effectiveness in reducing fatal crashes, they have not been met with uniformly positive support from stakeholders. Road users may be resistant to J-turn implementations due to actual or perceived increases in throughput time or physical constraints on farm vehicles and commercial trucks. However, educational efforts are not always successful in swaying stakeholder opinion, especially on polarizing issues, as people may become entrenched in their beliefs when confronted with contrary information (Lord et al., 1979).

Therefore, to develop a compelling set of persuasion tools, the persuader would ideally understand the broader background of persuasion and narratives. Persuasion is understood as any change in attitude that results from exposure to a communication message (Petty & Cacioppo, 1986). There are several theoretical explanations surrounding messages and persuasion. A large body of research on affect and persuasion pertains to the dual-process models that propose persuasion is a result of the mental

responses of a message (Chaiken & Trope, 1999; Dillard & Peck, 2000). Arguably, two of the most highly recognized dual-process models include the Elaboration Likelihood Model (Petty & Cacioppo, 1986) and the Heuristic-Systematic Model (Chaiken et al., 1989). The Elaboration Likelihood Model (ELM) posits message persuasion is emphasized through either the central or peripheral route to attitude change. In the central route, the recipient is typically influenced by rational factors and information relevant to the message, while the peripheral route typically influences the recipient by factors such as positive or negative cues within the persuasion context (Petty & Cacioppo, 1984; Braverman, 2008). Similarly, the Heuristic-System Model posits systematic processing is contemplative, analytic, and responsive to argument quality and relies on considerable cognitive effort, while heuristic processing relies on shortcut decision-making rules (e.g., source identity, non-content cues) to construct an attitude toward persuasive advocacy (Chaiken, 1980; Chaiken et al., 1989; Dillard & Peck, 2000).

One way to communicate messages is through narratives. A narrative is an umbrella term for personal stories, examples, testimonials, and entertainment-education content that offers increased comprehension, interest, and engagement (Shen et al., 2015; Dahlstrom, 2014). Narratives have been used in health communication as a tool to improve attitudes and knowledge and motivate health-behavior change (Hinyard & Kreuter, 2007; Lipsey et al., 2020). Similarly, research suggests that narratives can influence individual attitudes toward public policies, can encourage individuals to accept messages about disliked groups, and may be particularly valuable to certain population sub-groups (Kreuter et al., 2010; Slater et al., 2015; Wojcieszak & Kim, 2016; Lipsey et al., 2020).

Storytelling or sharing a personal perspective is an essential form of human communication and a vehicle for human connection (Lipsey et al., 2020). Testimonials present information in a personal format and may include a personal story, a description of an individual experience, or an opinion (Braverman, 2008; Keer et al., 2013). Communication messages delivered through testimonials are a powerful persuasive tool because they capture attention, evoke emotion, and entrance listeners in a manner that reduces resistance to the message (Krause & Rucker, 2020). Furthermore, using testimonials as a persuasive messaging strategy may be an effective way to shift viewer beliefs toward attitude-resistant topics. This phenomenon known as transportation— the feeling of being absorbed and caught up with the story itself—is a fundamental outcome of narrative involvement in the process of persuasion (Green & Brock, 2000; Dunlop et al., 2010; Banerjee & Green, 2012). Narrative transportation is related to enjoyment and perception that the narrative topic was personally relevant (Quintero Johnson & Sangaland, 2017). Additionally, transportation influences cognitive and affective responses and is considered a key mechanism of attitude, belief, and behavior change (Green & Brock, 2000; Banerjee & Green, 2012; Green & Clark, 2012). Greater transportation is associated with story-consistent beliefs and a greater liking for story protagonists and leads to fewer critical thoughts (Green & Brock, 2000; Van Laer et al., 2014).

Various individual and situational factors affect an individual's motivation and ability to process a message carefully (Petty & Cacioppo,1986; Olson & Zanna, 1993). Individual difference factors, such as those high in need for cognition, are more likely to be affected by argument quality, the recall of more message arguments, and an increase in the time spent deliberating the message (Cacioppo et al., 1983). Message processing may also be influenced by factors such as personal involvement and personal

relevance. Personal involvement, the motivational state induced by an association between an activated attitude and some aspect of self-concept, may moderate the type of persuasion that occurs (i.e., central or peripheral) (Johnson & Eagly, 1989; Petty et al., 1981). Specifically, increased involvement enhances the importance of message content (Petty & Cacioppo, 1979; Braverman, 2008). Similarly, when stories are personally relevant, story receivers may be more inclined to evaluate the story carefully and to generate critical thoughts related to that story (Van Laer et al., 2014). When the message is personally relevant, the effectiveness of the persuasive message is a function of cogency, whereas when the message is an issue of relatively low personal relevance, the effectiveness is a function of peripheral cues (Petty et al., 1981).

Other factors such as the number of arguments or speakers may influence message processing whereby increasing the number of arguments either enhances issue-relevant cognitive activity (i.e., the central route) or a person may agree because of the perception that there are a lot of arguments to support the message (Petty & Cacioppo, 1984). Moreover, the number of speakers in conjunction with the number of arguments can play an important role in persuasion, where multiple-source and multiple-arguments produce more favorable thoughts and are more persuasive compared to multiple arguments presented by a single source or multiple sources presenting a single argument (Harkins & Petty, 1981).

Choosing a storyteller that has strong ties to the audience facilitates a greater connection between the audience and the storyteller, making the narrative more effective (Escalas 2004; 2007). Persuasive tools should humanize the message by using real people and their stories (Machell et al., 2009). A likable and trustworthy communicator has a greater ability to persuade and influence the receiver (Chaiken & Eagly, 1983; Andreoli & Worchel, 1978). In fact, a highly credible source can increase message-relevant thinking for personally relevant counter-attitudinal issues as well as influence persuasion for those with extreme initial attitudes (Heesacker et al., 1983; McGinnies, 1973).

1.3 RESEARCH GOALS AND BASIC APPROACH

First, this work sought to determine whether the experience of driving on a J-turn and various J-turn signage strategies were enough to improve novice drivers' initial experiences with J-turns and attitudes toward J-turns. After reporting baseline attitudes, participants drove on simulated J-turns with varying levels of signage, which can contribute to how confusing or understandable a J-turn is to navigate for drivers new to J-turns. By manipulating levels of signage and assessing performance and subjective reporting of confusion and attitudes, the research team was able to draw preliminary conclusions on how signage levels, performance, confusion, and attitudes toward J-turns were related for drivers unfamiliar with J-turns.

Second, this work sought to identify effective educational and messaging strategies that can be used to communicate nontraditional road treatments to community members and stakeholders to improve public acceptance and buy-in toward their implementation. A series of studies evaluated the efficacy of using educational materials and various messaging strategies to improve attitudes toward J-turns. These studies attempted to experimentally manipulate the mode of communication to determine whether there were certain modes that were more effective either uniformly across all demographics, or

whether some modes (e.g., brochure, video, testimonial, simulation) were more effective for some demographic groups, allowing for tailoring of the message. A follow-up study considered the qualities of testimonials in more detail, given that this was a ubiquitous method of persuasion across disciplines.

Finally, after identifying multiple effective educational and messaging materials, the materials were packaged into a short presentation given to J-turn stakeholders and at a community engagement demonstration scheduled for an upcoming J-turn implementation project.

RCUT was the most frequently used term in this study, although some alternative names, including J-turn, were used interchangeably in study materials provided to participants. To bring terminology in line with other states, the use of "RCUT" has been replaced by the state engineers with J-turn. This paper will reference the intersection as J-turn for better continuity with future discussion.

1.4 SCOPE AND LIMITS OF RESEARCH

The scope of this research has several boundaries. First, the targeted population in the study is somewhat broad (i.e., Minnesota drivers). The implementable conclusions drawn from these studies are similarly applicable at this level. If there are targeted implementations for broader groups of people (e.g., drivers in the United States) or specific groups (e.g., drivers in Bemidji that do not like roundabouts), the conclusions here may not smoothly transfer to these groups. Second, the primary assessments here are focused on self-reported attitudes. Self-reported attitudes do not necessarily mean that people behave the same as their reported attitude, as there is only a moderate correlation between the two, as demonstrated by several meta-analyses (Ajzen, et al., 2018). As an example, high reported approval of J-turns may not necessarily mean these people will not complain to public representatives for installation of a J-turn near their residence. Behaviors may also be governed more by social norms and social pressure instead of attitudes (Wallace et al., 2005), so the results here will not transfer to all socio-cultural targets of persuasion (e.g., highly insular communities). Finally, while the simulator study should have reasonable generalizability to the real world, given the simulator task has high fidelity to the real-world task (Morris et al., 2021), the simulator studies should be replicated in a field setting.

1.5 GENERAL ORGANIZATION OF REPORT

- Chapter 2. Simulated J-turn Driving Performance Test
    - This chapter describes a study examining drivers' looking behaviors, navigational performance, and subjective experiences when navigating through simulated J-turn intersections with various levels of signage.
- Chapter 3. Evaluation of Persuasive Messaging Techniques
    - This chapter reviews a series of persuasive messaging studies to examine the influence of various messaging techniques on changing attitudes toward J-turns.
- Chapter 4. Messages to the Public

    - These two studies review the effects of a packaged presentation using the materials derived from the persuasive messaging studies reviewed in Chapter 3 to a group of stakeholders and a group of community members in Minnesota.
- Chapter 5. Conclusions and Recommendations.
- References
- Appendices

CHAPTER 2: SIMULATED J-TURN DRIVING PERFORMANCE TEST

The aim of this task was to examine drivers' looking behaviors, navigational performance, and subjective experiences when navigating through simulated J-turn intersections with various levels of signage. The present work analyzes several behavioral metrics relevant to participants' navigational maneuvers at conventional and J-turn intersections, including 1) participants' common driving errors, 2) simulated driving performance, 3) coded driver head movements, 4) intersection subjective measures, and 5) their qualitative feedback.

A total of 36 participants took part in the driving simulator study. Each participant completed five drives that consisted of two conventional intersections (i.e., 4-lane divided highway), followed by three J-turn intersections with various levels of J-turn signage (i.e., minimum signage, moderate signage, or full signage). Participants were instructed to make a left turn at any intersection they came across. Due to technical errors or motion sickness, 4 J-turn drives (or intersections) were excluded from the analysis (176 drives remained).

First, visualizations of participant navigational paths through each intersection were used to compare the participant's chosen path against the optimal path. For J-turn intersections, participants' chosen paths were coded for both critical and non-critical errors. For those who did not experience critical errors (i.e., successfully made left turns using J-turns), their driving performance data were further extracted from the driving simulator and examined within different road segments of the chosen path. Overall, the order in which participants were exposed to J-turn (i.e., either first-time use or subsequent uses) appeared to be a most significant factor that affected the differences in participants' driving errors and driving performance while navigating J-turns.

Next, video files extracted from the eye tracking system were coded independently by two trained coders. Initial testing found fixation measures near signage to be too noisy and infrequent toward the forward roadway to allow for meaningful analyses. The vast majority of gazes were directed far to the left and to the right, outside of the eye tracker's ability to measure fixations, toward mainline traffic. To capture this looking tendency, the video streams were analyzed to assess participants' head movements while navigating conventional and J-turn intersections. Participants made significantly fewer head movements at J-turn intersections compared to conventional intersections. Although not statistically significant, navigating the J-turn intersections was generally perceived to require lower mental effort, was less stressful, irritating, and easier to navigate compared to conventional intersections.

Finally, this deliverable also summarizes the qualitative data collected through participant feedback and comments to better synthesize the experience drivers had in navigating various levels of J-turn signage.

2.1 METHOD

2.1.1 Participants

In total, 44 participants consented to complete the simulation study. Five participants experienced simulation sickness, were dismissed from the study, and their data was excluded from the analysis. Two were dismissed due to technical issues with the driving simulator. Of the remaining participants, 36 participants completed the entire study. One participant completed four out of five experimental drives of the study, but a technical issue prevented data collection in the final drive. All participants were licensed Minnesota drivers with at least two years of driving experience. For gender, 15 identified as female (41.7%) and 21 as male (58.3%). The average age was 42.03 years (SD = 18.17), with a range from 20 to 75 years of age and a median age of 37. For education, two (5.4%) reported having a high school diploma or GED, nine (24.3%) had some college, no degree, 16 (43.2%) had a bachelor's degree, and nine (24.3%) had a graduate or professional degree. For race and ethnicity, 26 (70.3%) identified as White, four (11.0%) participants identified as multiracial, four (11.0%) identified as Hispanic or Latino, two (5.4%) identified as Asian, and one (2.7%) identified as Black or African American. For location, 22 (59.4%) of participants reported living in urban areas, 14 (37.8%) of participants reported living in suburban areas, and one (2.7%) reported living in rural areas.

2.1.2 Materials and Measures

2.1.2.1 Driving Behavior and Demographic Measures

***Attitude toward J-turns*.** Five items assessed participant attitudes and prior knowledge toward J-turns, such as "Do you think J-turns are a good idea?" The scale uses a 7-point Likert response ranging from 1 (i.e., definitely not) to 7 (i.e., definitely). Items 3, 4, and 5 were used to assess participants' pre- and post-J-turn attitudes.

Acceptance of Roundabouts. Two items were added to conclude the survey to assess drivers' general experience and acceptance of roundabouts. Participants reported their experience driving on a roundabout on a 4-point scale and reported their level of support for a roundabout to be placed in their community on a 7-point scale.

Use of GPS or Navigation System. One item assessed how often participants used a GPS or navigation system while driving. Participants reported frequency of using a GPS or navigation system using a 5-point scale.

***Demographics*.** Participants completed basic demographic information including age, gender, race, ethnicity, education, and zip code.

2.1.2.2 Intersection Subjective Measures

***Rating Scale Mental Effort*.** The rating scale of mental effort (RSME) is a univariate scale used for rating the degree of mental effort required to complete a task. The RSME consists of a 150-millimeter line marked with nine anchor points, each with a descriptive label indicating the degree of effort. Increases in ratings suggest an increase in mental workload.

Intersection Evaluation. Participants completed four items for each of the five intersections, which asked them to indicate the degree to which each intersection was confusing, stressful, irritating, and easy to navigate on a 5-point Likert Scale.

2.1.2.3 Driving Behavior Measures

Coded J-turn Errors. An optimal path for navigating J-turns was created to code for errors while navigating the J-turn. Errors were coded using a binary coding system (1 = yes, 0 = no). Coded J-turn errors included both critical and non-critical errors. Critical errors occurred when drivers failed to correctly make the left-turn using J-turns. These errors included driving the wrong way on the intersection (i.e., participant cut through center) and missing the U-turn (i.e., participant turned right and drove along the highway without entering the U-turn).

Non-critical errors occurred when drivers managed to use the J-turn to turn left but failed to drive with the intended steps of the optimal path (Figure 2.1). During the pre-U-turn phase, non-critical errors included entering the left lane, right lane, or right shoulder from the stop sign when turning right onto the highway, straddling a lane (pre-U-turn), and making a late turn into the deceleration lane (see Appendix A for definition). During the post U-turn phase, non-critical errors included making a U-turn into the right (far) lane, not changing lanes into the right lane after the U-Turn, straddling a lane line (post U-turn), and making multiple U-turns. See Appendix A for illustrations on specific J-turn driving errors.

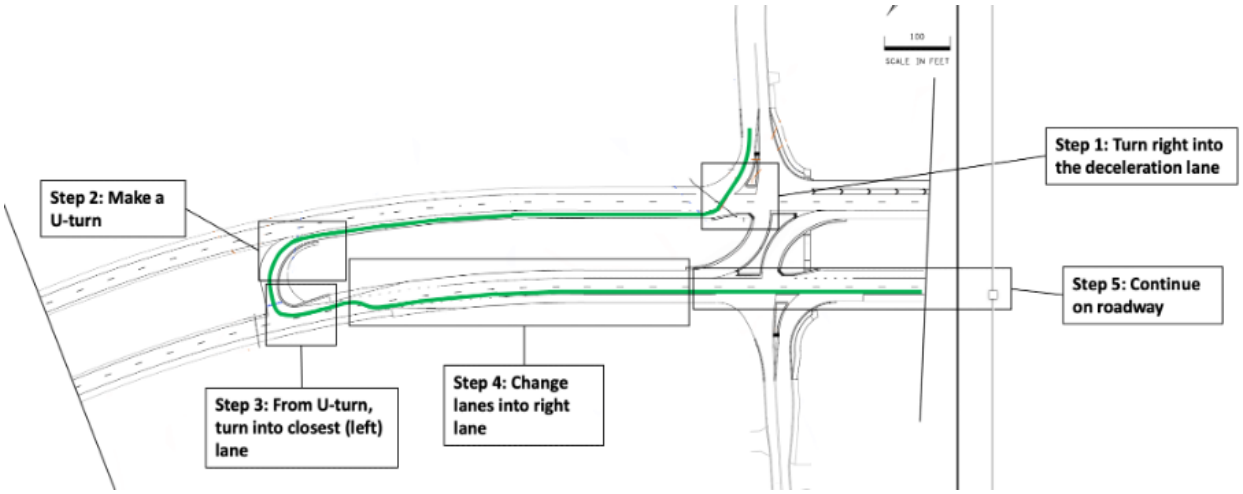

Figure 2.1 Optimal path for J-turn navigation.

Simulated Driving Performance. Participants' chosen path was delineated into a sequence of road segments through various starting (or ending) points, including:

- P2 denotes the entry point of the intersection zone, where the participant pulls to a stop behind the stop bar and is prepared to turn into a conventional or J-turn intersection.
- P3 starts when the participant's vehicle passes the edge of the nearest driving lane on the highway, which is the same for all intersections.
- P4 starts when the participant enters the deceleration lane of J-turn or the median of the conventional intersection.
- P5 denotes the entry point of the U-turn for J-turn (i.e., not available for the conventional intersection).
- P6 starts when the subject enters the driving lane of the opposite direction at either the J-turn intersection or after crossing the median.

Four driving performance measures were analyzed, including 1) minimal speed (in miles per hour—mph); 2) average speed (in mph); 3) time spent (in seconds), and 4) distance traveled (in feet). These measures were extracted, separately, for each road segment. Data during the P6 segments were removed from the analysis as drivers were observed to intentionally reduce their speed or stop to fill in the surveys administered between each drive.

Coded Head Movements. Participants' head movements were coded for each of the five drives by two trained coders. The first two drives (i.e., Drive 1 and Drive 2) were through conventional intersections and the remaining drives (i.e., Drive 3, Drive 4, and Drive 5) were J-turn intersections. Coded head movements included looking left (i.e., left head turn), looking right (i.e., right head turn), and total head turns made by participants at each of the five intersections. A full head turn right or left was defined as the participant turning their head away from the forward-facing camera (see Figure 2.2). A head turn was counted once the participant's head position returned to face forward.

Figure 2.2 Still shots of cameras capturing head turning of participants navigating J-turn.

2.1.2.4 Qualitative Measures

Verbal Feedback. Participants were asked to think aloud as they navigated through the experimental simulated drives and encouraged to provide feedback about J-turns, such as how easy it was to navigate, what they liked or disliked, what was confusing or frustrating about J-turns, and suggestions for improvement.

2.1.3 Procedure

Recruited participants completed an online screening questionnaire and baseline attitude measures prior to completing the simulation study. Participants who reported greater than "some familiarity" with J-turns and those with a history of motion sickness were excluded from the simulation study. Next, the research team emailed eligible participants to schedule a time to complete the driving simulation study. For the simulation portion of the study, participants completed informed consent and demographic information. Next, participants completed a practice drive in the driving simulator and the wellness questionnaire to determine whether they were experiencing symptoms of simulation sickness. Next, all participants completed five experimental drives. The first two drives consisted of a traditional four lane, divided highway intersection. The final three drives consisted of J-turn intersections (see Figure 2.3) that varied in the amount of signage (i.e., full, minimum, or moderate). The order of signage was counterbalanced.

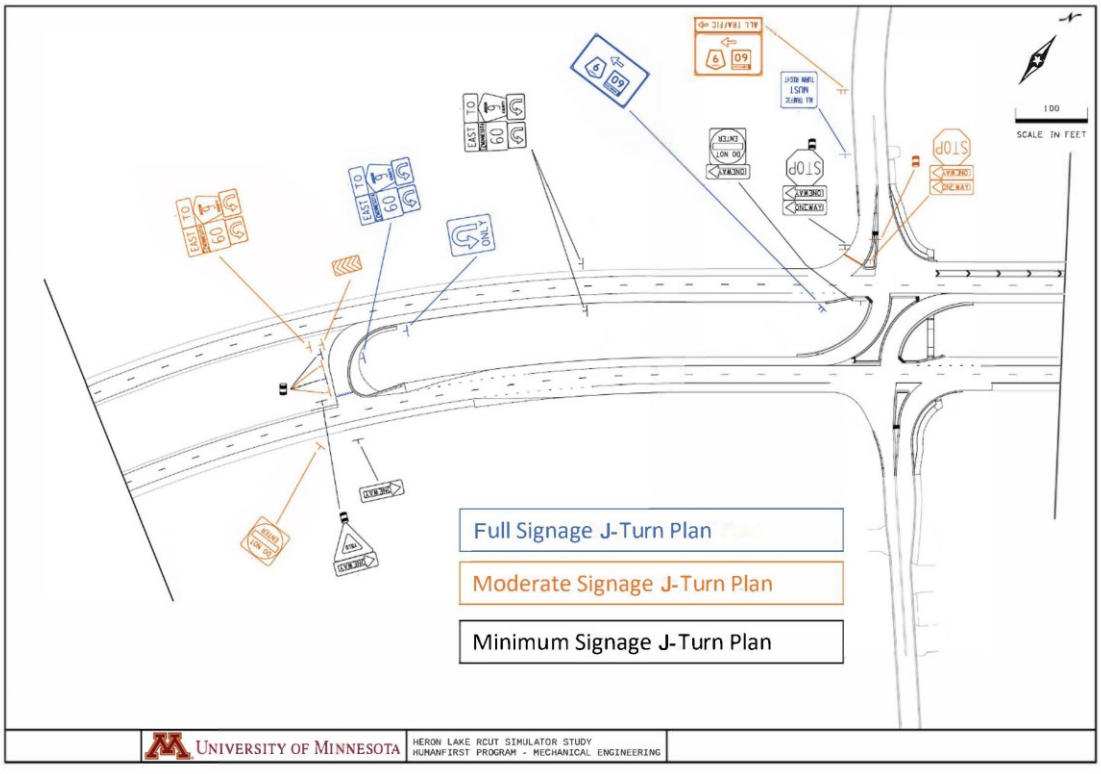

Figure 2.3 Diagram of three levels of J-turn signage with only black signs in minimum condition, black+orange in moderate condition, and black+orange+blue in full signage condition.

For all drives, participants were given instructions to take a left at the intersection. After each drive, participants were instructed to stop to complete self-report measures about the intersection. After completing the experimental drives, participants completed post-test attitude measures and provided verbal feedback about their experience navigating J-turns.

2.1.4 Statistical Methods

The analysis consists of three components that examines various driver behaviors toward using:

1) J-turn intersections
2) Conventional intersections, and
3) How these behaviors compare between conventional and J-turn intersections.

Independent variables included Signage Type (i.e., minimum signage, moderate signage, and full signage, see Appendix B) and First-time Use (i.e., yes versus no). Specific levels of the Signage Type may not be applicable if the analysis was conducted among J-turn only or conventional intersections only. Participants' age (i.e., continuous variable) and their previous experience with J-turns (i.e., 0 = no experience driving with J-turns, and 1 = rare or occasional experience driving with J-turns), were included in the models as covariates.

Generalized estimating equations, along with various regression models, were applied to account for the correlations within repeated measures on the same participant. For the continuous outcomes (i.e., simulated driving performance), normal regressions were used to estimate the mean difference across different levels of predictors. Logistic regressions were used to estimate the odds ratios of the binary outcomes (i.e., coded J-turn errors). Tukey-Kramer tests were used to adjust for pairwise comparisons. In addition to the quantitative analysis, a summary of the qualitative feedback was provided.

2.2 RESULTS

2.2.1 J-turn Intersections

2.2.1.1 Coded J-turn Driving Errors

For each J-turn drive, the visualization of each J-turn chosen path was reviewed and coded, separately, by two coders. The initial agreement rate between the two coders was 91.3% across all types of coded J-turn driving errors (1 = yes, 0 = no). All coding differences (i.e., n = 103 non-critical errors) were identified and reviewed together by coders to reach a decision that best matched with the coding manual. Finally, opinions from a third coder were utilized to determine the remaining disagreements with twelve driving errors pertinent to straddling the lane(s) (i.e., errors 4, 5 or 10).

Table 2.1 provides descriptive statistics for various driving errors by the order of exposure to J-turn. The results are summarized in the following:

- Critical Error
    - Participants were more likely to make a critical driving error when they were first exposed to the J-turns (i.e., 19.4% for the first-time use versus 2.9% for subsequent uses, aggregating over Error types 1 and 7, see Table 2.1).
    - Error Type 1 persisted for only one participant across all three J-turn drives.
- Non-critical Error (Pre U-Turn phase)
    - Rather than turning directly into the deceleration lane of J-turns (i.e., the intended path), the most commonly adopted navigational maneuver was to first turn right into either the right (near) or left (far) lane of the intersection, followed by merging into the deceleration lane.
    - Error Types (2) and (3): Compared to the first-time use, drivers were significantly more likely to enter the left (far) lane of the intersection from stop sign (i.e., Error type 2) during the subsequent uses (Odds ratio = 5.68, 95% CI = 1.75 to 18.42). Equivalently, they were less likely to make the Type 3 error (i.e., enter the right lane from stop sign).
    - Error Type (6): Compared to the first-time use, the odds of participants' turning late into the deceleration lane was 0.3 times of that during the subsequent uses (Odds ratio = 0.29, 95% CI = 0.13 to 0.62).
- Non-critical Error (Post U-turn phase)
    - Error Types (8) and (9): Participants were slightly more likely to turn into the right (far) lane and continued to drive in that lane (i.e., a decreased percent in Error type 9), during the subsequent uses of J-turns. However, this behavioral change was not significantly affected by Signage Type or First-time Use.
    - Error Type (11): Participant who experienced this error were all older drivers (aged 67, 69 and 75, respectively).
- Non-critical Straddle Error
    - Error Types (4), (5), and (10): Due to limited observations, the straddle error was recoded (i.e., 1 if either of the three straddle errors occurred; 0 if none). The result shows no significant main effect or interaction effect.

Table 2.1 Descriptive frequencies and percentages of participants' driving errors while navigating J-turns

Type of Error	First-time Use		Subsequent Uses	
	N = 36 drives		*N* = 68 drives	
	N	%	*n*	%
Critical Error				
Type 1: Wrong way on intersection (i.e., drove through center)[a]	1	*2.8*	2	*2.9*
Type 7: Did not make a U-turn[a]	6	*20.7*	0	*0.0*
Non-critical Error[b]				
Pre U-Turn phase				
Type 2: Entered left (far) lane from stop sign[c]	6	*20.7*	35	*53.0*
Type 3: Entered right (near) lane from stop sign[c]	20	*69.0*	30	*45.5*
Type 4: Entered right shoulder from stop sign or straddle right lane	6	*20.7*	7	*10.6*
Type 5: Straddle deceleration lane (Pre U-Turn)	3	*10.3*	9	*13.6*
Type 6: Late turn into deceleration lane (< = 250 feet away from the U-turn)[c]	21	*72.4*	31	*47.0*
Post U-Turn Phase				

Type 8: Made U-turn into right (far) lane	6	*20.7*	19	*28.8*
Type 9: Did not change lanes into right lane after U-turn	18	*62.1*	39	*59.1*
Type 10: Straddle lane or swerving (Post U-Turn)	4	*13.8*	13	*19.7*
Type 11: Made multiple U-turns[a]	1	*3.4*	2	*3.0*

a. Statistical models did not converge due to a limited number of observations.
b. The total number of drives were 29 for the first-time use and 66 for the subsequent uses, excluding those drives that contained a critical error.
c. The main effect of first-time use was significant (*ps* < 0.01).

2.2.1.2 Simulated J-turn Driving Performance

Minimal speed (in mph). There was a significant main effect of first-time exposure for the minimal speed during the P3 segment ($\chi 2$ = 8.33, p = 0.0039). Compared to the first drive (M = 15.62, SD = 8.00), participants' minimal speed was significantly greater during the subsequent drives (M = 19.04, SD = 6.28, Mean difference = 3.90, 95% CI = 1.72 to 6.08).

During the P5 segment, a borderline significant interaction effect of Signage Type and First-time Use was found ($\chi 2$ = 6.00, p = 0.0497), which appeared to be driven by a smallest average minimal speed during the first-time exposure to the full signage J-turn (M = 0.02, SD = 0.08). None of the pairwise comparisons were significant for this interaction effect. Overall, a slightly slower minimal speed was found to be associated with increased age, during P3 and P4 segments (p < 0.05, and p < 0.01, respectively).

Average speed (in mph). The interaction effect of Signage Type and First-time Use was significant for the average speed measure during the P3 segment (χ^2 = 6.15, p = 0.0461). This effect was mainly driven by the difference between the minimum signage J-turn condition (M = 27.78, SD = 4.01) and the moderate signage J-turn condition (M = 30.93, SD = 4.65) during the subsequent uses (Mean Difference = -3.08, 95% CI = -5.93 to -0.22).

There was a significant main effect of First-time Use on the average speed (χ^2 = 9.94, p = 0.0016), after participants drove into the deceleration lane and before they entered the U-turn (i.e., P4 segment). Compared to the first-time exposure to J-turn (M = 23.82, SD = 9.51), participants drove at a significantly faster average speed during the subsequent exposures (M = 27.96, SD = 9.63), Mean difference = 5.19, 95% CI = 3.04 to 7.35. The average speed among drivers was 0.24 mph slower associated with one unit of increase in age, during the P4 segment (p < 0.01).

During the P5 segment, there was a significant main effect of Signage Type (χ^2 = 7.41, p = 0.0246). Participants had a significantly lower speed with the full signage J-turn (M = 10.61, SD = 4.01) compared to the minimum signage J-turn (M = 11.62, SD = 4.56, Mean Difference = -1.66, 95% CI = -2.83 to -0.50). The differences between the moderate signage J-turn (M = 10.60, SD = 4.01) and others were not significant.

Time spent (in seconds). During the P2 segment, there was a significant main effect of first-time use (χ^2 = 5.60, p = 0.0180). Compared to the first time of navigating J-turn (M = 15.38, SD = 14.38), participants spent significantly less time waiting at the intersection during the subsequent exposures (M = 9.17, SD = 5.35, Mean difference = -6.17, 95% CI = -10.79 to -1.55).

During the P4 segment, the effect of first-time use was also significant (χ^2 = 5.50, p = 0.0190), Participants spent a significantly longer amount of time during the subsequent exposures (M = 5.62, SD = 4.02), compared to the first-time use (M = 3.91, SD = 4.68, Mean difference = 1.83, 95% CI = 0.47 to 3.18).

Distance traveled (in feet). During the P2 segment, a borderline significant effect of First-time Use was found (χ^2 = 3.85, p = 0.0497). Participants traveled slightly longer when they navigated J-turns for the first time (M = 96.48, SD = 37.29) than during the subsequent exposures (M = 85.07, SD = 16.57, Mean difference = 11.80, 95% CI = 0.85 to 22.76).

There was also a significant main effect of First-time Use during P3 and P4 segments ($p < 0.01$). Compared to the first-time use (M = 421.27, SD = 212.57), participants drove a significantly shorter distance prior to merging into the deceleration lane during the subsequent uses (M = 333.92, SD = 201.49, Mean distance = -98.08, 95% CI = -155.66 to -40.50). The direction of such a comparison was reversed during the P4 segment.

2.2.2 Conventional Intersections

2.2.2.1 Coded Conventional Intersection Driving Errors

Failure to turn left. For the conventional intersections, two participants (aged 50 and 29, respectively) failed to correctly make the left-turn maneuver as instructed. One participant drove straight through the conventional intersection and continued to drive straight onto the minor road on the opposite side. The other participant missed the median and turned directly to the right lane of the intersection. Overall, participants were less prone to experience the defined critical driving errors navigating conventional intersections than J-turns (i.e., 1.4% versus 8.6% of all drives, respectively).

2.2.2.2 Simulated Conventional Intersection Driving Performance

Stop in the median. The present analysis also examined the likelihood of drivers to make a stop in the median of a conventional four-lane divided highway intersection before turning left. After removing the two erroneous drives, participants in this study were found to go through the median of the conventional intersections during 32 drives (i.e., 45.7% of all 70 drives). There was no significant difference between novice and subsequent uses of the conventional intersections.

2.2.3 Comparisons Between J-turns and Conventional Intersections

2.2.3.1 Simulated Driving Performance

Time spent prior to entering the intersection (i.e., P2 segment). There was a significant main effect of Signage Type ($\chi2$ = 14.55, p = 0.0022). Compared to the conventional intersection, drivers took significantly less time to enter the intersection at the minimum signage and moderate signage intersections. The main effect of first-time use was also significant ($\chi2$ = 6.83, p = 0.0090), with drivers

spending less time on deciding to proceed into the intersection during the subsequent exposures to the intersections (see Table 2.2).

Average speed during the P2 segment. During the P2 segment, participants were found to drive significantly faster for all J-turn intersections, compared to conventional intersections ($\chi2 = 18.07$, $p = 0.0004$). The main effect of first-time use was also significant ($\chi2 = 4.46$, $p = 0.00347$) (see Table 2.2).

Time spent upon turning left into the lane (i.e., P3 through P5 segments). There was a significant main effect of Signage Type ($\chi2 = 30.49$, $p < 0.0001$). In the present driving simulator study, participants spent more time navigating J-turns than conventional intersections (see Table 2.2).

Table 2.2 Comparisons of simulated driving performance between J-turn and conventional intersections by Signage Type and First-time Use

	Waiting/Decision-Making Phase (i.e., P2 segment)				Left-turning Phase[b] (i.e., P3 through P5 segments)	
	Time[a] (in seconds)		Average speed[a] (in mph)		Time (in seconds)	
	Mean (SD)	Mean Difference [95% CIs]	Mean (SD)	Mean Difference [95% CIs]	Mean (SD)	Mean Difference [95% CIs]
Signage Type						
Conventional	18.72 (11.61)	----	3.41 (2.87)	----	8.39 (4.43)	----
Minimum signage	9.83 (6.51)	**-7.77 [-12.87, -2.67]**	8.75 (5.44)	**4.86 [2.26, 7.46]**	24.87 (8.73)	**16.44 [11.24, 21.63]**
Moderate signage	10.72 (6.66)	**-7.54 [-11.52, -3.57]**	6.84 (3.30)	**3.39 [1.81, 4.96]**	25.49 (6.13)	**17.18 [14.52, 19.85]**
Full signage	13.13 (12.91)	-4.29 [-11.81, 3.23]	7.13 (4.74)	**3.34 [1.14, 5.36]**	26.63 (10.32)	**19.19 [14.82, 23.55]**
First-time Use						
Yes	17.53 (13.24)	----	5.01 (4.23)	----	16.62 (11.08)	----
No	12.05 (8.25)	**-4.81 [-8.06, -1.55]**	6.47 (4.58)	**1.26 [0.16, 2.36]**	19.42 (11.00)	-0.91 [-2.53, 0.70]

a. None of the pair-wise comparisons was significant across all three J-turn signage.
b. Data were included in the analysis for those experimental drives, where participants managed to successfully make the left-turn, at either the conventional or J-turn intersections.

2.2.3.2 Coded Head Movements

The frequencies of left, right, and total head movements were calculated by averaging the observed numbers between the two coders. There were significant main effects of Signage Type (all *ps* < 0.001) and First-time Use (all *ps* < 0.05). Participants made significantly fewer head movements for scanning traffic at all J-turn intersections, compared to conventional intersections. None of the pairwise comparisons across J-turn intersections were significant. The frequency of head movements was slightly smaller in the subsequent exposures (see Table 2.3).

Table 2.3 Comparisons of coded head movements between J-turn and conventional intersections by Signage Type and First-time Use

	Left Head Turn *M*		Right head Turn *M*		Total *M*	
	Mean (SD)	Mean Difference [95% CIs]	Mean (SD)	Mean Difference [95% CIs]	Mean (SD)	Mean Difference [95% CIs]
Signage Type						
Conventional	4.68 (2.42)	----	4.23 (2.43)	----	8.91 (4.56)	----
Minimum signage	2.47 (1.17)	**-2.10 [-3.05, -1.14]**	2.25 (1.78)	**-2.03 [-2.88, -1.19]**	4.72 (2.61)	**-3.84 [-5.38, -2.30]**
Moderate signage	2.82 (1.59)	**-1.88 [-2.80, -0.96]**	2.09 (1.45)	**-2.10 [-3.13, -1.08]**	4.91 (2.73)	**-3.99 [-5.80, -2.17]**
Full signage	2.76 (1.27)	**-1.80 [-2.63, -0.98]**	2.10 (1.63)	**-1.80 [-2.88, -0.73]**	4.87 (2.33)	**-3.89 [-5.77, -2.02]**
First-time Use						
Yes	4.11 (2.36)	----	3.57 (2.64)	----	7.69 (4.60)	----
No	3.07 (1.80)	**-0.64 [-1.08, -0.20]**	2.60 (1.81)	**-0.65 [-1.21, -0.10]**	5.68 (3.37)	**-1.29 [-2.18, -0.41]**

2.2.3.3 Intersection Subjective Measures

As shown in Table 2.4, there was a significant main effect of First-time Use for all subjective measures (all *ps* < 0.05). In general, participants reported experiencing less mental workload, and identified subsequent uses as less confusing, stressful, and irritating when navigating the signs, as compared to the first-time use. The signs were also reported to be easier to navigate once they had been exposed to them. Although not statistically significant, the moderate signage J-turn appeared to outperform the other J-turn signage levels and the conventional intersections in almost all aspects (except for the 'confusing' measure).

Specifically, for the 'confusing' measure, there was a significant interaction effect of Signage Type and First-time Use ($\chi 2$ = 14.97, p = 0.0018). The minimum signage J-turn was rated to be significantly more confusing than the conventional intersection (Mean difference = 0.64, 95% CI = 0.02 to 1.26) (see Table 2.4). For the 'irritating' measure, participants who reported having had a previous experience (rare or occasional) driving with J-turns perceived the signs to be more irritating (*M* = 2.99, *SD* = 1.31), compared to those who did not report having any previous J-turn experience (*M* = 2.34, *SD* = 1.17, Mean difference = 0.61, 95% CI =0.09 to 1.13).

Table 2.4 Comparisons of intersection subjective measures between J-turn and conventional intersections by Signage Type and First-time Use

	Mean (SD)	Mean Difference [95% CIs]
Mental Workload		
Signage Type		
Conventional	55.00 (25.33)	----
Minimum signage	56.08 (34.54)	1.61 [-12.99, 16.22]
Moderate signage	54.70 (32.16)	2.45 [-11.60, 16.51]
Full signage	63.12 (34.09)	9.48 [-4.63, 23.59]

First-time Use		
Yes	62.26 (28.80)	----
No	52.84 (30.94)	**-11.77 [-17.90, -5.64]**
Confusing		
Signage Type		
Conventional	2.15 (1.15)	----
Minimum signage	2.66 (1.33)	**0.64 [0.02, 1.26]**
Moderate signage	2.42 (1.25)	0.50 [-0.11, 1.11]
Full signage	2.65 (1.30)	0.56 [-0.17, 1.29]
First-time Use		
Yes	2.72 (1.24)	----
No	2.18 (1.21)	**-0.83 [-1.12, -0.54]**
Stressful		
Signage Type		
Conventional	3.07 (1.14)	----
Minimum signage	2.77 (1.35)	-0.25 [-0.87, 0.38]
Moderate signage	2.70 (1.21)	-0.26 [-0.91, 0.38]
Full signage	2.47 (1.24)	-0.10 [-0.74, 0.53]
First-time Use		
Yes	3.18 (1.03)	----
No	2.71 (1.29)	**-0.48 [-0.84, -0.12]**
Irritating		
Signage Type		
Conventional	2.72 (1.25)	----
Minimum signage	2.57 (1.38)	-0.08 [-0.87, 0.70]
Moderate signage	2.45 (1.23)	-0.21 [-0.83, 0.42]
Full signage	2.47 (1.24)	-0.20 [-0.95, 0.55]
First-time Use		
Yes	2.79 (1.29)	----
No	2.45 (1.23)	**-0.37 [-0.64, -0.10]**
Easy to navigate		
Signage Type		
Conventional	3.00 (1.14)	----
Minimum signage	3.14 (1.35)	0.08 [-0.57, 0.73]
Moderate signage	3.36 (1.22)	0.15 [-0.49, 0.78]
Full signage	3.09 (1.19)	0.04 [-0.56, 0.65]
First-time Use		
Yes	2.81 (1.11)	----
No	3.00 (1.23)	**0.59 [0.26, 0.91]**

Qualitative Feedback. A total of 23 participants (62.2%) provided qualitative feedback about their experience driving the simulated J-turns. Participant feedback was coded for key themes related to participants' experience in the driving simulator. Frequencies and percentages were calculated for the themes. Although some of the most common feedback related to uncertainty regarding the deceleration lane, many participants also showed support for J-turns and roundabouts (i.e., a similar novel roadway). Additionally, many participants reported there was a need for additional information about how to navigate J-turns, such as with additional signage, lane markers, or symbols. However, many participants reported that J-turns were easier to navigate once they had completed the first J-turn (i.e., Drive 3) and that it was an educational experience. A handful of participants (*n* = 4 or 17.4%) indicated that they still preferred the conventional intersections, stating that they felt they had more control or because they disliked J-turns. Table 2.5 presents a summary of coded themes, sample feedback, frequencies, and percentages.

Table 2.5 Summary of Coded Feedback, Examples, Frequencies, and Percentages.

Theme	Sample Feedback	*n* (%)
Deceleration lane uncertainty	*Not sure what to do with my turn signals. Did not feel safe merging across two lanes of traffic. Felt uncomfortable crossing traffic. Difficult to cross over.*	13 (56.5)
Support for J-turns or roundabouts	*Feels faster and safer. Only had to watch traffic one direction at a time. J-turns are preferable on very busy roads. It is clear what you need to do.*	13 (56.5)
Need for additional information	*Include a sign with a symbol to show you what to do, add painted lines on the roadway (e.g., arrows). Provide instruction prior to U-turn. Bold and darken signage words. Use lights.*	11 (47.8)
Learning experience	*First time navigating J-turn was tough but got the hang of it on the second attempt. This was a very educational experience. Much more comfortable with the J-turn after the initial drive. A lot easier and less confusing [the 2nd and 3rd time].*	7 (30.4)
Preference for conventional intersections	*The conventional intersection feels like I have more control.*	4 (17.4)
No difference in J-turn signage levels	*Did not notice difference between sign levels*	4 (17.4)

Overall Feedback. Overall, many participants reported that driving on J-turns felt less stressful than driving on conventional intersections, they felt safer while driving on J-turns, liked that the J-turn only required you to focus on one direction of traffic at a time, and felt that driving on J-turns was an educational experience. Several participants reported that they did not notice a difference between the amount of signage while driving on the J-turn (i.e., minimum signage, full signage, or moderate signage).

Initial Reactions to Driving on J-turns. Many participants indicated that their initial experience driving through the J-turn in the simulation was difficult, frustrating, confusing, or felt overwhelming. Although many participants indicated initial dislikes toward J-turns, many participants indicated that they got used to driving on the J-turn and were able to use the information available (i.e., signage) to determine how they should proceed through the second and third J-turn. Overall, participants generally indicated that

their first experience crossing the J-turn was challenging but felt that once they were able to "practice" and gain experience driving through one J-turn, the remaining J-turns were easier to navigate and understand.

Concerns and Frustrations about J-turns. One of the most common points of concern about driving on J-turns pertained to completing the U-turn portion of the J-turn. Participants expressed strong concern in several areas including:

- Feeling that it was difficult or uneasy to cross the highway (i.e., multiple lanes) to get to the left lane in order to make the U-turn
- Feeling confused about when they should switch lanes to make the U-turn
- Being unsure about how to properly signal that they were making a U-turn

Additionally, a few participants reported a general dislike for J-turns even after completing the full driving simulation. One participant said they did not like driving on J-turns because they felt like they had more control when driving through a conventional intersection. Others said they would feel worried if they had an older vehicle because they felt like they would not be able to accelerate quickly enough after making the U-turn. One participant commented that people are not typically thinking about slowing down on the highway [to make a U-turn].

2.3 DISCUSSION

2.3.1 J-turn Intersections

The effect of First-time Use. Participants were more likely to make a critical driving error when they were first exposed to J-turns (19.4% for the first-time use versus 2.9% for subsequent uses). Positive behavioral adaptations were identified toward using J-turns, during the subsequent drives. Specifically, participants tended to spend less waiting/decision-making time at the intersection, were more likely to enter the left (far) lane from the stop sign, made fewer late-turn errors into the deceleration lane (or equivalently, traveled a longer distance for the P4 segment), and had a faster average traveling speed before entering the U-turn (i.e., P4). These findings suggested that participants were better aware of the intended J-turn path and felt less hesitation about using the deceleration lane to make a left turn.

The effect of Signage Type. Participants had the slowest driving speed to clear the U-turn in the full signage J-turn condition (i.e., P5 segment). Many were also found to pull to a stop or near stop within the U-turn when they were first exposed to a J-turn with full signage. Participants also tended to drive faster through the P3 segment (i.e., potentially less confusion and hesitation while exiting the minor road) at moderate signage J-turns compared to minimum signage J-turns during the subsequent uses. These results may potentially reflect a less appropriate level of information provided by full signage or minimum signage J-turns.

2.3.2 Comparisons between J-turns and Conventional Intersections

The effect of First-time Use. A similar effect of First-time Use has been consistently identified for coded head movements and intersection subjective measures – subsequent exposures to the intersections improved driver performance and subjective ratings.

The effect of Signage Type. Participants were less prone to experience critical driving errors navigating conventional intersections than J-turns. During the waiting/decision-making phase (i.e., P2 segment), participants spent less time at the stop sign in the minimum signage and moderate signage conditions compared to conventional intersections (i.e., 7.8 and 7.5 seconds shorter, respectively). Waiting times were not significantly different between conventional intersections and the J-turns with full signage, however. Moreover, participants drove much faster at J-turn intersections compared to conventional intersections. In this study, participants took about 16.4 to 19.2 seconds longer making the left-turn using various levels of J-turns (average value of 25.66 seconds across all three J-turn signage types), compared to conventional intersections (average value of 8.39 seconds).

Compared to conventional intersections, participants used significantly fewer head movements for scanning traffic at J-turn intersections, regardless of the signage levels. Although not statistically significant, navigating the J-turn intersections was generally perceived to require lower mental effort, was less stressful, irritating, and easier to navigate, compared to conventional intersections. However, minimum signage J-turns were perceived to be significantly more confusing than conventional intersections. Additionally, moderate signage J-turns appeared to receive the highest subjective ratings across all levels of J-turn signage, which may be the most appropriate signing level for both novice and experienced drivers.

2.3.3 Limitations

The present study has several limitations. First, the study power to detect an actual effect may be restricted by a small sample size within specific sub-levels of Signage Type and First-time Use ($n < 10$). Additionally, missing data due to motion sickness or technical errors (such as simulator corruptions) might also introduce bias to the study estimations.

Second, the study demonstrated potential advantages of J-turns over conventional intersections, including a shorter decision-making time, less frequent head movements, and better subjective ratings. However, the total time for clearing a left turn was found to be longer using J-turns than conventional intersections, which potentially indicates a lack of efficiency for J-turns, although this is not a primary rationale for installing J-turns. This could be due to several potential reasons. On one hand, participants were observed to drive at a much slower speed on the major road (posted speed limit of 55 mph) in the present driving simulator setting, and many reported they would not have done so in the real-world. One the other hand, the operational performance of J-turns has been found to be subjective to intersection traffic conditions (e.g., traffic volumes, flow patterns, queue lengths, etc.). It was suggested that J-turn intersections outperform conventional intersections on highly trafficked, major roads and light-traffic minor roads (Bared, 2009). Generally, this is thought to happen because J-turns constrain

the traffic flow of drivers turning left or going straight from the minor road, which is problematic for high traffic volume at minor roads. In the case of traditional intersections, high volumes on the major road significantly prohibit traffic flow from the minor road, but the J-turn's design limiting conflict points allows for better traffic flow from the minor road during high traffic volume conditions on the major road as minor road vehicles only must attend and merge with one direction of traffic. However, this benefit is reduced when major road traffic volumes decrease (Al-Omari & Abdel-Aty, 2021). These factors may also potentially affect the generalizability of the study findings.

Another limitation of this study was the inability to track eye fixations of the participant in relation to individual signage of each intersection. Participants tended to prioritize head gazes to traffic on the mainline roadway, which exceeded the range of eye tracking ability of the system. The extent to which drivers were able to extract sign information during saccades (i.e., eye movements rather than fixations) or through peripheral vision is unknown. Future studies may examine driver fixations in a driving simulation where they are not required to look for traffic as they interpret the intersection to increase the likelihood that they might prioritize looking at signage.

2.3.4 Overall Recommendations

The study provides several practical recommendations regarding future applications of J-turn intersections. First, educational programs and other community initiatives should be promoted to provide better knowledge of J-turns to a broader range of novice and experienced drivers. Providing step-by-step guidance of how to navigate a J-turn, along with basic information about their need and benefits, should help to guide novice drivers through them upon their first exposure. In addition to other materials, using a portable driving simulator as a training tool might also be considered to provide novice drivers with an immersive, interactive experience to support educational materials during outreach events.

The moderate signage condition appears to provide the most appropriate levels of information to guide drivers compared to the minimum signage or full signage J-turns. Notably, many current J-turns in Minnesota use the full signage model for signing, while some select districts use the moderate signage model. Not only is it possible that the full signage condition is resulting in suboptimal efficiency and workload for drivers, but it may also unnecessarily use resources (i.e., labor and materials) for installation and maintenance of signs that are not necessary for safety.

CHAPTER 3: EVALUATION OF PERSUASIVE MESSAGING TECHNIQUES

The findings from the driving simulator study suggested simulated experience alone may not be powerful enough to increase acceptance and buy-in of novel roadway designs. As a result, the research team conducted a series of persuasive messaging studies to examine the influence of various messaging techniques toward novel roadway designs (specifically J-turns). First, an initial study at the Minnesota State Fair tested the influence of different persuasive messaging strategies on attitude and attitude change toward J-turns. The outcome of the State Fair study suggested that, while other techniques can be effective, testimonials (i.e., narrative storytelling) could be particularly effective for multiple target audiences. Therefore, a follow-up study was conducted to analyze the effectiveness of different types of testimonials on different audience demographics. Finally, a partial replication of the State Fair study was conducted online to better target the rural population of Minnesota, as rural communities are common target audiences for persuasion of the benefits of J-turns. In summary, this portion of the project focuses on persuasive messaging approaches (e.g., testimonials) on attitude change toward J-turns, and comprises three studies: 1. State Fair Study, 2. Testimonial Study, 3. Large Sample Study (online).

State Fair Study. The goal of the State Fair study was to test the effectiveness of various presentation methods on the ability to change attitudes on J-turns. The State Fair component of the study ended at the conclusion of four allotted shifts provided by the Driven to Discover (D2D) facility at the State Fair, on Sept 25th, 2019. This study tested four different presentation methods about J-turn designs, including basic/PowerPoint, videos, testimonials, and simulation. Participants took a series of questionnaires, indicated their prior attitudes, and then were exposed to information about J-turns through one of the four aforementioned persuasive messaging conditions. The results suggested that testimonials (i.e., narrative storytelling) was a particularly effective messaging strategy for multiple target audiences. As such, there was a need to examine the effectiveness of different types of testimonials on different audience demographics.

Testimonial Study. The goal of the testimonial study was to understand which components of a persuasive testimonial (e.g., speaker perception, degree of immersion) resonated with different types of viewers. First, survey metrics with the greatest chance of capturing the influence of testimonials on decision-making were selected based on a literature survey. Next, participants were recruited across the state of Minnesota. Previous testimonials, including videos that were not previously tested at the Minnesota State Fair, were re-examined to determine which of them could be included in the online survey for further testing. Analysis of the data suggested that Minnesota residents living outside of the seven-county metro may have greater acceptance to J-turns if they are presented with videos that contain messages that elicit greater cognitive responses (e.g., more thoughts about the topic), and in turn, show greater attitude change from their initial position on J-turns. Conversely, those living inside the seven-county metro showed greater attitude change on J-turns when presented with a speaker who presented a testimonial that was immersive (i.e., elicited greater narrative transportation into the story) and when the speaker was high in key personal attributes (e.g., being perceived as knowledgeable, credible, trustworthy).

Large Sample Study. The large sample study utilized the identified testimonials from testimonial study and a partial replication of the State Fair study to assess attitudes toward J-turns across a more diverse sample of Minnesotans. An online survey first provided a brief overview of J-turns and assessed initial participant attitudes toward J-turns. Select metrics which were found to be predictive of J-turn acceptance in the testimonial study were integrated into the study for measurement. Following baseline measurements, participants were randomly assigned to watch one of four presentation methods (PowerPoint, Video, Narrative Storytelling with Testimonials, Immersive Simulation) and asked to rate their perception of the presentation and their attitudes toward J-turns after they had completed the presentation. For those living in urban areas, greater attitude change resulted from a presentation that was perceived to have a good message (e.g., had a strong argument, was carefully thought out) and that made the viewer think about the content (e.g., how it could affect their own lives, the consequences of high-risk intersections). This suggests that the informational video or the PowerPoint presentation would result in the greatest attitude change for urban participants. For those living in suburban areas, greater attitude changes also resulted from a presentation that made the viewer think about the content, but also one that elicited a greater degree of feeling immersed in the story (i.e., level of transportation). This suggests that for suburban participants, the simulation presentation or the informational video would result in the greatest attitude change. Finally, for those living in rural areas, the greatest attitude change was a result of those presentations that were perceived to have a good message. This suggests that either the simulation or the narrative storytelling would result in the greatest attitude change for rural participants.

3.1 METHOD

3.1.1 Participants

State Fair Study. A total of 354 participants signed the informed consent to join the study at the Minnesota State Fair. Analyzable (i.e., either partial or complete) data was recorded for 340 participants. The average age of participants was 43.27 (*SD* = 16.72), with a range between 17 and 88 years of age and median of 46.5. For conditions, 85 participants were assigned to the brochure condition, 82 participants were assigned to the video condition, 85 participants were assigned to the testimonial condition, and 88 participants were assigned to the simulation condition.

Testimonial Study. A total of 162 participants participated in the study. The average age was 49.59 (*SD* = 16.94), with a range between 20 to 81 years of age and a median age of 50.

Large Sample Study. A total of 446 participants responded to the study listings for the large sample study. Of those who initiated participation for the study, 43 participants provided only partial responses, resulting in a sample size of 403 participants who completed the online study. The average age was 41.36 years (*SD* = 16.10), with a range between 18 to 83 years of age and a median age of 38. Participants were randomly assigned to one of four experimental conditions with 91 participants assigned to the immersive simulation condition, 109 participants assigned to the video-based presentation condition, 104 participants assigned to the non-video-based presentation condition, and 99 participants assigned to the narrative storytelling condition.

Table 3.1 Participant Demographic Characteristics for State Fair, Testimonial, and Large Sample Studies

	State Fair Study		Testimonial Study		Large Sample Study	
Characteristic	*n*	%	*n*	%	*n*	%
Minnesota Resident						
Yes	304	89	161	99	388	96
No	36	10.5	1	< 1	15	4
Geographic Location						
Seven-County Metro	264	86	96	59	163	42
Greater Minnesota	42	14	66	41	225	58
Population Size						
Urban or Large Town (> 10,000)	294	87	139	86	272	71
Small Town or Rural (< 10,000)	44	13	19	14	112	29
Gender						
Female	168	49	-	-	184	46
Male	171	50	-	-	219	54
Nonbinary	1	< 1	-	-	0	0
Race						
White	282	83	154	95	363	90
Asian	38	11	3	2	10	2
Black or African American	3	1	0	0	3	1
American Indian or Alaska Native	0	0	1	1	5	1
Hispanic or Latino	11	3	0	0	7	2
Multiracial	9	3	2	1	13	3
Native American	2	1	0	0	0	0
Hawaiian	1	< 1	0	0	0	0
Other	0	0	1	1	9	2
Education						
Some high school	4	1	1	1	11	3
High school diploma/GED	27	8	5	3	49	12
Associate degree	29	9	11	6	46	11
Some college	46	14	14	9	96	24
Bachelor's degree	124	36	63	39	131	33
Advanced degree	110	32	68	42	68	17

Note. State Fair Study Sample *N* = 340; Testimonial Study *N* = 162; Large Sample Study *N* = 403

3.1.1.1 State Fair Study

Acceptance of J-turns. Three items assessed participant pre and post attitudes toward J-turns, such as "Do you think J-turns are a good idea?" The scale uses a 7-point Likert response ranging from 1 (definitely not) to 7 (definitely).

Presentation Experience. Two items assessed participants' presentation experience including how much the participant enjoyed the presentation and whether the participant would recommend the presentation to others.

3.1.1.2 Testimonial Study

Level of Personal Involvement. Two items assessed participants' level of personal involvement and used a 5-point response set. Participants rated how important it was for roadway designs to be changed to improve safety and how happy they were with the state of Minnesota roadways.

Acceptance of J-turns. Five items assessed participant attitudes and prior knowledge toward J-turns, such as "Do you think J-turns are a good idea?" The scale uses a 7-point Likert response ranging from 1 (definitely not) to 7 (definitely). Items 3, 4, and 5 were used to assess participants' pre- and post-J-turn attitudes. With the present sample, the three-item scale showed strong internal consistency for both pre-J-turn attitude ($\alpha = .90$) and post J-turn attitude ($\alpha = .92$) measures.

Level of transportation. Three items assessed the level of transportation participants experienced after watching each video, such as, "The video affected me emotionally" and "The events in the video are relevant to my everyday life." The scale uses a 7-point response format ranging from 1 (not at all) to 7 (very much). With the present sample, the scale showed strong internal consistency, $\alpha = .72$

Cognitive responses. Four items were used to assess the cognitive response to each testimonial, such as "Overall, how much did this make you think about how intersection design can affect your life?" The scale uses a 5-point response format from 1 (not at all) to 5 (a great deal). With the present sample, the scale showed strong internal consistency, $\alpha = .73$.

Cognitive processing. Two items assessed the cognitive processing valence, sample item "Considering the video, did you agree or disagree with building Restricted Crossing U-Turn intersections (J-turns) at high-risk intersections?" The scale uses a 5-point response format ranging from 1 (strongly disagree) to 5 (strongly agree). With the present sample, the scale showed strong internal consistency, $\alpha = .92$

Affective responses. Two items asked participants to indicate how the video made them feel (i.e., negative to positive) and the degree of intensity of that feeling (i.e., low to high), using a 5-point response format. These two affective response items were scored separately.

Perception of speaker. (Ruckey et al., 2009; Wood et al., 1985; Wood, 1982). Six items were adapted to assess the participant perception of the speaker in each video. With positive poles: knowledgeable, likable, unbiased, credible, trustworthy, expert on a 7-point response set. With the present sample, the scale showed strong internal consistency, $\alpha = .89$

Perception of the message. (Wood et al., 1985). Three items were modified using 7-point response scales to rate the strength of the message, how carefully thought out the message was, and how convincing the message was. With the present sample, the scale showed strong internal consistency, α = .93

Acceptance of roundabouts. Two items were added to conclude the survey to assess drivers' general experience and acceptance of roundabouts. Participants reported their experience driving on a roundabout on a 4-point scale and reported their supportiveness for a roundabout to be placed in their community on a 7-point scale.

3.1.1.3 Large Sample Measures

The same measures used in the testimonial study were used in the large sample study, with some modifications. Two additional measures were added to the large sample study to assess participant need for cognition and participation ratings of presentation experience.

Need for Cognition. Six items assessed participants' need for cognition, such as "I would prefer complex to simple problems" and "I really enjoy a task that involves coming up with new solutions to problems." The scale uses a 6-point response set, ranging from 1 (not characteristic of me at all) to 6 (extremely characteristic of me).

Presentation experience. Two items assessed participants' presentation experience including how much the participant enjoyed the presentation and whether the participant would recommend the presentation to others.

3.1.2 Research Design

3.1.2.1 State Fair Study Design

The research design was a 4 x 2 mixed factorial design with four between-subjects conditions of presentation (Brochure, Video, Testimonial, and Simulator) and two within-subjects measures of self-reported attitudes on J-turns (i.e., pre- and post-presentation).

STATE FAIR STUDY PRESENTATION CONDITIONS

Brochure Condition. The basic or brochure condition had the research team give participants a brochure (see Figure 3 and 4) and a PowerPoint. There were ten slides in the PowerPoint, which restated the information in the brochure as well as the video in the Video condition. The PowerPoint was administered to balance out the time and educational content between conditions.

Video Condition. The video condition presented participants with a video on J-turns. The video was designed by MnDOT and Nighthawk Marketing. The video was 2 minutes and 38 seconds long.

Testimonial Condition. The testimonial condition also used a series of videos. The first video was the J-turn video used in the video condition. The other videos were testimonials by people with exposure to J-turns throughout Minnesota who had the opportunity to talk about their experiences. These individuals included a grocery operations manager and grocery store owner in Jordan, Minnesota (video approximately 2:28 long), a city administrator of St. Peter, Minnesota (video approximately 2:22 long), and an older parent and driver from Willmar, Minnesota (video approximately 1:48 long). The testimonial condition was significantly longer than the other conditions, totaling approximately 9 minutes and 16 seconds long.

Simulator Condition. The driving simulation condition had participants watch the MnDOT J-turn video that was shown in the video condition, and then manually drive through a simulated J-turn using the HumanFIRST portable driving simulator (see Figure 3.1). The Portable Driving Environment Simulator, manufactured by Realtime Technologies, is a complete driving simulator mounted on a portable chassis. The portable simulator consists of a driver seat, vehicle controls (pedals, steering, and transmission), and vehicle gauges on a custom-fabricated chassis. Five 32-inch high-definition displays provided the forward view. The drive took approximately a minute and required participants to make a left turn on a J-turn (e.g., right turn into turning lane, make U-Turn, and continue straight). See Figure 3.2 for a bird's eye view of the J-turn used in the simulation.

Figure 3.1 HumanFIRST Portable Simulator at the Minnesota State Fair in 2019.

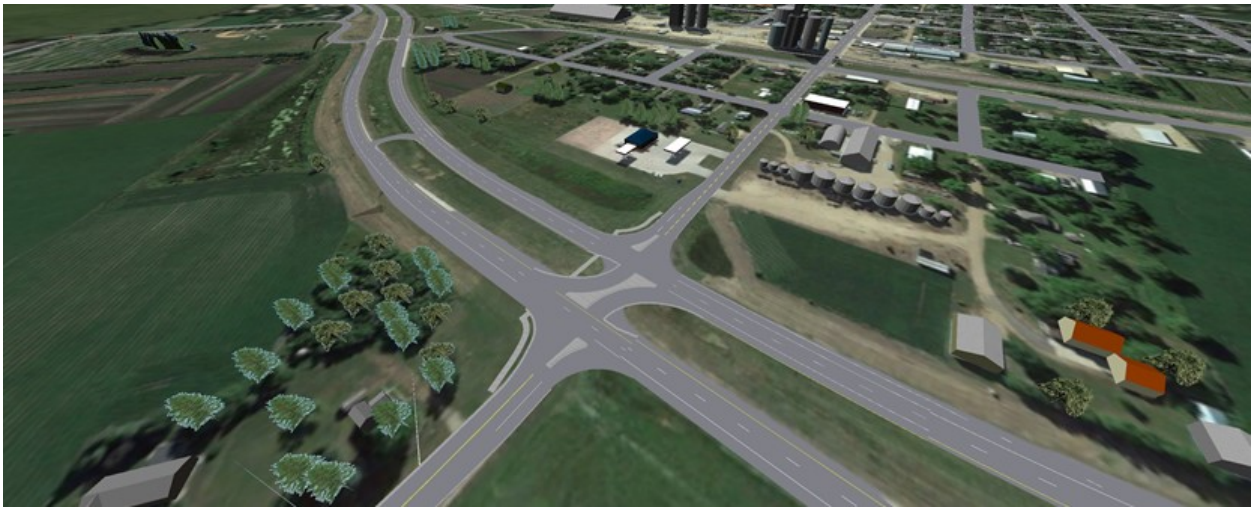

Figure 3.2 Birdseye image of simulated J-turn intersection used in the State Fair simulation condition.

STATE FAIR PROCEDURE

Prior to the start of data collection, participants were briefly screened with the Screening Questionnaire (Appendix C) and provided with a general background and explanation of the study. After participants read and signed an Informed Consent Form, they were assigned a participant number. Participants completed a demographic questionnaire required by D2D for the State Fair, a driving history questionnaire, an attitudes survey on J-turns, and a series of personality questionnaires (Appendix C). These questionnaires were administered on an iPad via Qualtrics, which was provided by the State Fair D2D staff. The questionnaires took approximately 10 to 15 minutes to complete. They then were presented the material concerning J-turns, based on the condition they were assigned. Afterwards, they answered a series of questions about their attitudes about J-turns. The total study duration was approximately 15 to 30 minutes, depending on condition.

3.1.2.2 Testimonial Study Design

The research design was a 3 x 2 within-subjects design with three randomly selected testimonial videos and 2 levels of self-reported attitudes on J-turns (i.e., pre- and post-presentation). The primary analysis of interest was that of the self-reported attitudes on J-turns, with secondary analyses considering the characteristics of the observed testimonial videos.

Introduction to J-turns. Prior to assessing participants' baseline acceptance of J-turns, the survey provided basic informational slides to convey what J-turns are and how drivers can navigate them. These six slides were taken from the slide show used in the State Fair Study; however, any benefit information was excluded to limit any persuasion in J-turn acceptance prior to viewing the testimonials. Images of the slides can be found in Appendix C.

Testimonial Videos. Eight testimonial videos, created and provided by the Minnesota Department of Transportation, were used. Videos were coded by speaker characteristics, location, story type (i.e., personal, opinion, informational), and whether the speaker was talking about others' experience with J-turns. The mean length of the videos was 89 seconds, ranging from 68 to 108 seconds, see Table 3.2).

Table 3.2 General description of testimonials used in study.

Video	Speaker Description	Length (sec)	Speaker Gender	Speaker Age Group	Location	Story Type
A	Grocery Operations Manager	68	Female	Older Adult	Jordan, MN	Personal Story
B	City Administrator	78	Male	Middle-Aged Adult	St. Peter, MN	Informational
C	Grocery Store Owner	85	Male	Middle-Aged Adult	Jordan, MN	Informational
D	Young Driver	87	Male	Young Adult	Minneapolis, MN	Personal Story/Opinion
E	Vehicle Sales General Manager	89	Male	Middle-Aged Adult	St. Peter, MN	Informational, Personal Opinion
F	State Trooper	100	Male	Older Adult	Shakopee Region	Informational
G	Older/Parent Driver	108	Male	Older Adult	Willmar, MN	Personal Story/Opinion
H	Restaurant General Manager	102	Male	Young Adult	Jordan, MN	Personal Story/Opinion

TESTIMONIAL STUDY PROCEDURE

The survey was administered on an online platform (Qualtrics). Participants logged on, completed informed consent, demographic information, and driving pretest measures. Next, participants were randomly assigned to watch and rate three of the eight testimonial videos. The survey was restricted to not allow participants to proceed in the survey until sufficient time had passed that would have allowed the video to be fully watched. After participants watched and rated the three videos, they completed post-test measures and were debriefed. The survey took approximately 17 minutes to complete.

3.1.2.3 Large Sample Study Design

The research design was a 4 x 2 mixed factorial design with four between-subjects conditions of presentation and two within-subjects measures of self-reported attitudes on J-turns (i.e., pre- and post-presentation).

LARGE SAMPLE STUDY PRESENTATION CONDITIONS

Simulation. The simulation was 1 minute and 36 seconds long and was created using a 360-degree GoPro camera. The simulation video featured a vehicle navigating through the Huron Lake J-turn by arriving at the minor leg stop sign, turning right, making a U-turn, and proceeding forward to complete a left turn. The speed of the vehicle could not be controlled by the participant; however, the 360-video experience allowed participants to “look around” during the simulated drive by moving their smartphone with their hands or by clicking and dragging the cursor on a computer screen (see Figure 3.3). This allowed the participant to fully look left or right as a driver would while making decisions about gaps in traffic to proceed on to each new section of roadway while making the left turn. Prior to the simulation, six slides from the slide show used at the Minnesota State Fair were presented, with any

benefit information excluded, limiting any persuasion in J-turn acceptance to the immersive experience itself.

Figure 3.3 Screenshots of 360 video as the vehicle enters the U-turn on the J-turn.

Testimonial Videos (Narrative Storytelling). This condition consisted of the three testimonial videos that produced the greatest attitude change and/or contained speaker attributes that resulted in significant attitude changes in the testimonial study. The first video (1 minute, 41 seconds) was a personal story and opinion that consisted of a speaker who was an older adult, male parent from Willmar, MN. The second video (1 minute and 41 seconds) was an informational video that consisted of an older adult male who was a state trooper from the Shakopee region. The third video (1 minute and 19 seconds) was an informational video that consisted of a middle-aged adult male who was a city administrator in St. Peter, MN. Prior to viewing the testimonial videos, six slides from the slide show used at the Minnesota State Fair were presented, with any benefit information excluded limiting any persuasion in J-turn acceptance to the narrative storytelling experience itself. See Figure 3.4.

Figure 3.4 Screenshots of the testimonial videos 1, 2, and 3.

Informational Video Based Presentation. The informational video presentation consisted of a video on J-turns (presented as RCUTs), designed by MnDOT and Nighthawk Marketing. The video was 2 minutes and 38 seconds long. See Figure 3.5.

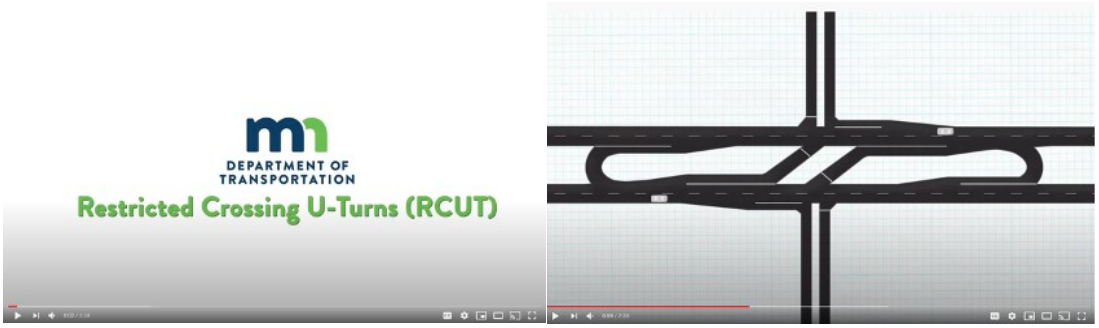

Figure 3.5 Screenshots of MnDOT video at start and mid-point.

PowerPoint (Non-video) Presentation. This condition consisted of an informational PowerPoint presentation was a non-video-based presentation consisting of a recorded presentation of ten slides on J-turns (presented as RCUTs) and was 3 minutes and 2 seconds long. See Figure 3.6.

Figure 3.6 Screenshots of PPT presentation at start and mid-point.

LARGE SAMPLE STUDY PROCEDURE

The survey was administered on an online platform (Qualtrics). Participants logged on, completed informed consent, demographic information, and pre-presentation measures. Next, participants were randomly assigned to one of four presentation conditions. The survey was restricted in Qualtrics to not allow participants to proceed until sufficient time had passed that would have allowed the presentation to be fully watched. After participants finished the presentation, they completed post-test measures and were debriefed. The median time to complete the survey was 15.62 minutes.

3.2 RESULTS

Frequencies and percentages were computed for participant knowledge of J-turns and experience with J-turns. Table 3.3 presents a summary of frequencies and percentages for all three studies.

Table 3.3 Frequencies and percentages for J-turn knowledge and J-turn Experience from State Fair, Testimonial, and Large Sample Studies

	State Fair Study		Testimonial Study		Large Sample Study	
	n	%	*n*	%	*n*	%
Knowledge of J-turns						
I have never heard of J-turns	199	58.5	53	33.5	126	31.3
I have heard of J-turns but am not very familiar	72	21.2	31	19.6	99	24.6
I have heard of J-turns and am somewhat familiar	47	13.8	53	33.5	125	31.1
I have heard or J-turns and am very familiar	22	6.5	21	13.3	52	12.9
Experience with J-turns						
I have never crossed a J-turn	214	62.9	57	36.1	126	31.3
I have crossed a J-turn once or twice	74	21.8	53	33.5	132	32.8
I occasionally cross J-turns	45	13.2	42	26.6	120	29.8
I frequently cross J-turns	7	2.0	6	3.8	24	6.0

Note. State Fair Study *N* = 340; Testimonial Study *N* = 158; Large Sample Study *N* = 402

Overall Attitudes Toward J-turns

Means and standard deviations were calculated for each attitude item and a summed attitude score across the State Fair, Testimonial, and Large Sample studies (Table 3.4). Paired samples t-tests were computed to determine whether there were meaningful differences in J-turn attitude change from pretest to post-test measures across the three conditions.

Table 3.4 Summary of Means and Standard Deviations for Pre- and Post-J-turn attitudes across State Fair, Testimonial and Large Sample Studies

	State Fair Study		Testimonial Study		Large Sample Study	
	Pre	Post	Pre	Post	Pre	Post
Good idea	3.86 (1.44)	5.13 (1.01)	4.84 (1.60)	5.64(1.53)	4.41 (1.57)	5.84 (1.38)
Willing to drive	4.65 (1.27)	5.35 (1.02)	5.78 (1.50)	6.13 (1.34)	5.66 (1.52)	6.31 (1.12)
Support in Community	3.98 (1.51)	5.00 (1.23)	4.89 (1.89)	5.50 (1.70)	4.39 (1.82)	5.62 (1.62)
Summed Attitude	-	-	15.60 (4.58)	17.27 (4.27)	14.46 (4.16)	17.77 (3.73)

Note. Standard deviations in parentheses. State Fair scores are on a 0-6 scale. For comparison to other studies, add 1 to each average of the State Fair Study Pre- and Post-scores.

State Fair Study Attitude Scores. There was a significant difference for participants' pre-J-turn attitudes scores to post-J-turn attitude scores for each of the attitude items (all ps < .001).

Testimonial Attitude Scores. There was a significant difference from pre-J-turn attitudes to post-J-turn attitudes in the belief that J-turns are a good idea, $t(140) = -6.391$, $p < .05$, willingness to drive on J-

turns, $t(140) = -3.71$, $p < .05$, and support for J-turns to be placed in the community, $t(140) = -4.50$, $p < .05$. This suggests that the testimonial videos influenced attitudes toward J-turns. A dependent samples t-test observed a significant difference from pre to post summed J-turn attitude score, $t(140) = -5.56$, $p < .001$, suggesting that attitudes toward J-turns improved after viewing the testimonials.

Large Sample Attitude Scores. Overall, there was a significant difference between participants' pre-J-turn attitudes and post-J-turn attitudes, $t(402) = -19.60$, $p < .01$. There was a significant difference from pre-J-turn attitudes to post-J-turn attitudes in the belief that J-turns are a good idea, $t(402) = -20.05$, $p < .01$, willingness to drive on J-turns, $t(402) = -11.66$, $p < .01$, and support for J-turns to be placed in the community, $t(402) = -16.65$, $p < .01$. This suggests that all presentation conditions positively influenced attitudes toward J-turns.

Additionally, to further examine attitude change, analyses were performed for participants who showed lower initial attitudes toward J-turns (N = 326). Participants were classified as having lower initial attitudes if they used a response set of 5 (possibly) or lower for each of the pre-J-turn attitude items, with a pre-J-turn attitude summed score less than or equal 15. Means and standard deviations were calculated for J-turn attitudes for participants who reported low initial support for J-turns. The greatest attitude change from pre to post attitudes was participant willingness to drive on a J-turn. Table 3.2 presents a summary of means and standard deviations for pre-J-turn attitudes and post-J-turn attitudes for all participants and low support participants.

Attitude change scores were computed by calculating the difference from pre- to post-J-turn attitudes scores. An independent-samples t-test was conducted to compare attitude change scores for low support and high support participants. There was a significant difference in attitude change scores from pre- to post-test J-turn attitudes for low support participants, $t(401) = -9.04$, $p < .01$. Participants with low initial support for J-turns showed greater attitude change ($M = 3.98$, $SD = 3.34$) compared to those with higher initial support for J-turns ($M = .44$, $SD = 1.65$). This suggests that participants with lower initial support for J-turns showed greater attitude change in post-treatment attitudes compared to those with higher initial support.

3.2.1 Predictors of Attitude Change

3.2.1.1 State Fair Study

POST-PRESENTATION J-TURN ATTITUDE BY CONDITION

Post-presentation J-turn attitude summed scores were examined across conditions, which ranged from 0 to 18, with higher scores implying better attitudes toward J-turns. Although not statistically different, the testimonial condition had the highest attitude score (M = 15.58, SD = 3.15), followed by the simulation (M = 15.49, SD = 2.68), the brochure/basic condition (M = 15.46, SD = 3.24) and the video condition (M = 15.35, SD = 3.19). There are no significant differences in attitudes per condition, when adding up attitude scores from the three scales.

Analyses observed that attitudes change on whether J-turns are a good idea and whether J-turns were good for the community interacted with other factors, while willingness to drive on a J-turn did not demonstrate significant interactions with other factors besides pre-post scores. With that in mind, the following analyses focus on the "J-turn: Good Idea?" and "J-turn: Good for Your Community?" questions.

J-turn Good Idea. The pre-education response to this question found 36% of participants reporting that J-turns were probably or definitely a good idea and 63% reported they are possibly to definitely a good idea. Following the educational treatments, 78% of participants reported that J-turns were probably or definitely a good idea and 94% reported they are possibly to definitely a good idea. Between-subject effects showed main effects of urban versus rural location of residence, $F(1,216) = 7.936$, $p = .005$ (Figure 3.7), as well as previous J-turn experience, $F(1,216) = 4.297$, $p = .039$ (Figure 3.8). There was a marginal effect of presentation condition by previous crash experience, $F(3, 216) = 2.421$, $p = .067$, see Figure 3.7 and Figure 3.8.

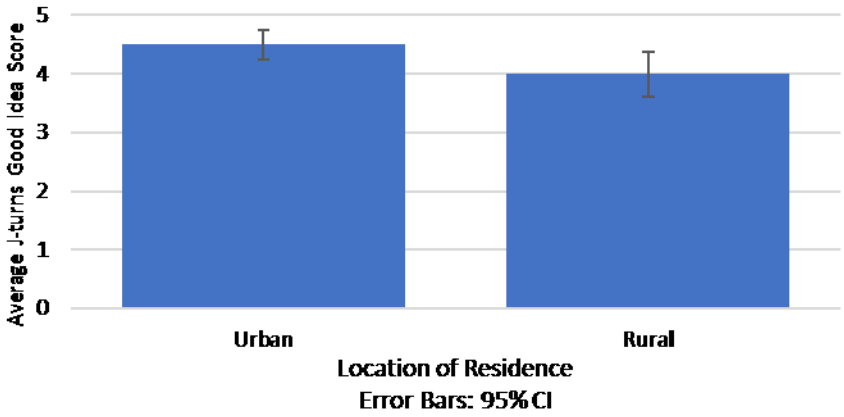

Figure 3.7 Averaged J-turn Good Idea score by urban/rural location.

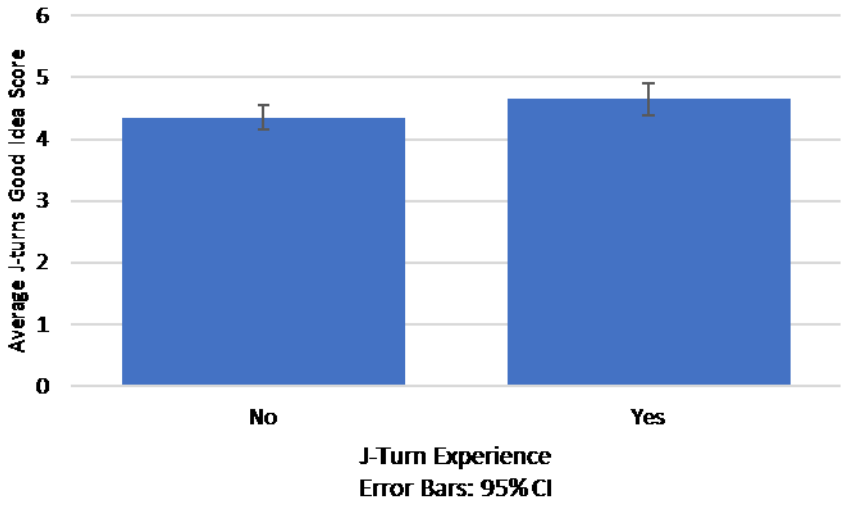

Figure 3.8 Averaged J-turn Good Idea score by prior J-turn Experience.

Direct analysis of attitude change (Post-Attitude – Pre-Attitude), when split by previous experience with crashes at intersections (or that of a loved one) found that when only looking at those who had no intersection crash experience, there was no significant difference of attitude change between presentation methods, $F(3, 122) = .893$, $p = .447$. See Figure 3.9. When looking at those who had intersection crash experience, there was a significant difference of attitude change between presentation methods, $F(3, 198) = 2.961$, $p = .033$. See Figure 3.10.

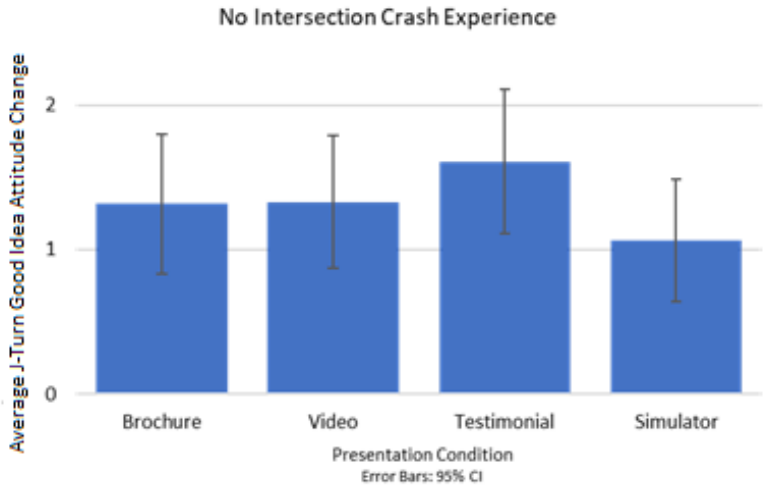

Figure 3.9 Good Idea Attitude change by presentation condition for drivers with *no* intersection crash experience.

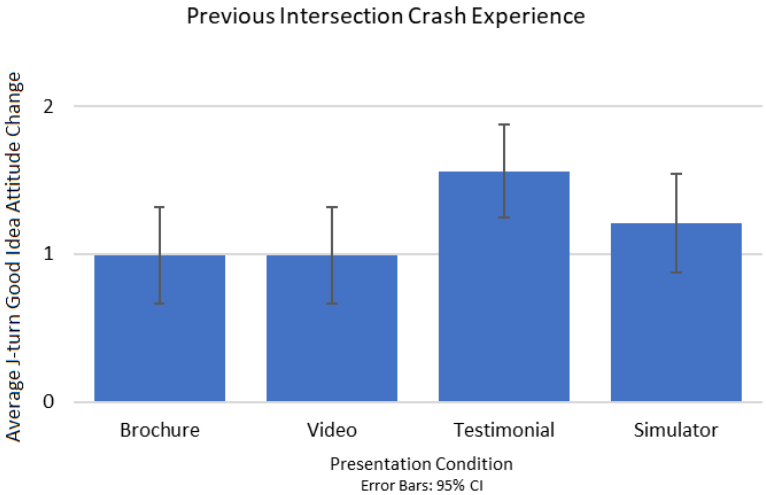

Figure 3.10 Good Idea Attitude change by presentation condition for drivers *with* intersection crash experience.

J-turn Community. The pre-education response to this question found 36% of participants would be supportive of a J-turn being placed in their community and 63% reporting they are possibly to definitely supportive. Following the educational treatments, 78% of participants would be supportive of a J-turn being placed in their community and 94% reporting they are possibly to definitely supportive. Looking at between-subject effects, there was a main effect of urban versus rural location of residence, $F(1,216) =$

4.467, p = .036, see Figure 3.11. There was also a main effect of previous J-turn experience $F(1,216) = 5.432$, $p = .021$, see Figure 3.12. Marginal interaction between presentation condition and prior intersection crash experience, $F(3, 216) = 2.298$, $p = .078$.

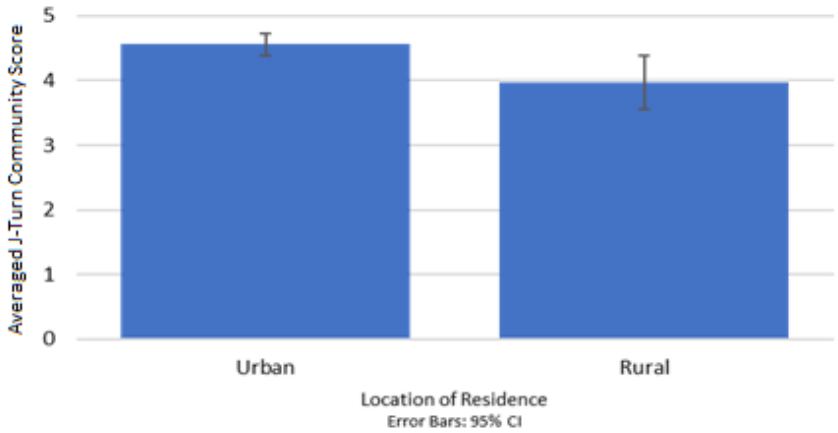

Figure 3.11 Averaged J-turn in Community score by urban/rural location.

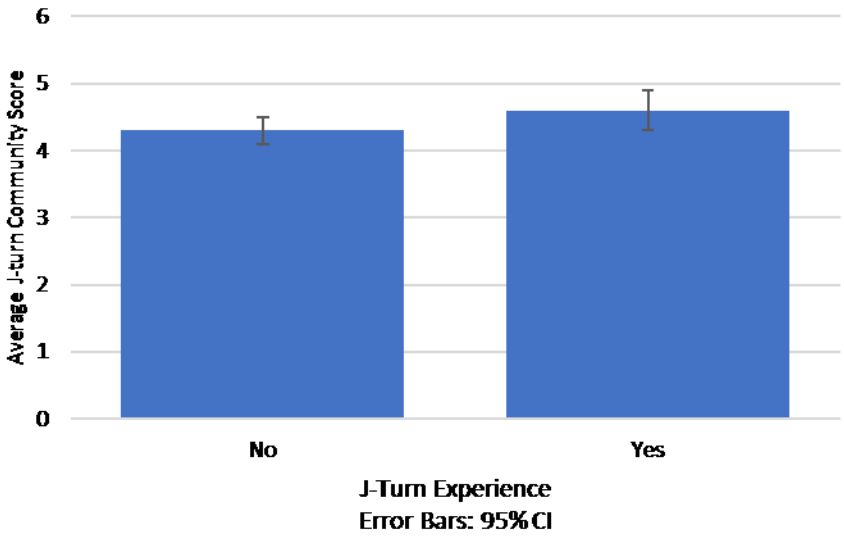

Figure 3.12 Averaged J-turn in Community score by prior J-turn Experience.

Direct analysis of attitude change (Post-Attitude – Pre-Attitude), when split by previous experience with crashes at intersections (or that of a loved one) found that when only looking at those who had no intersection crash experience, there was no significant difference of attitude change between presentation methods, $F(3, 122) = .934$, $p = .426$. See Figure 3.13. When looking at those who had intersection crash experience, there was a significant difference of attitude change between presentation methods, $F(3, 198) = 3.463$, $p = .017$. See Figure 3.14.

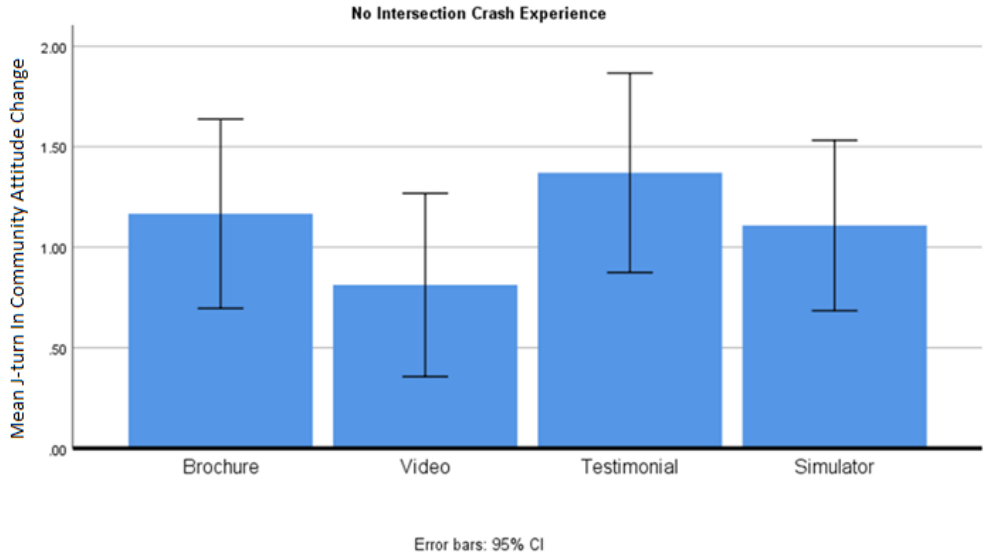

Figure 3.13 In Community Attitude change by presentation condition for drivers with *no* intersection crash experience.

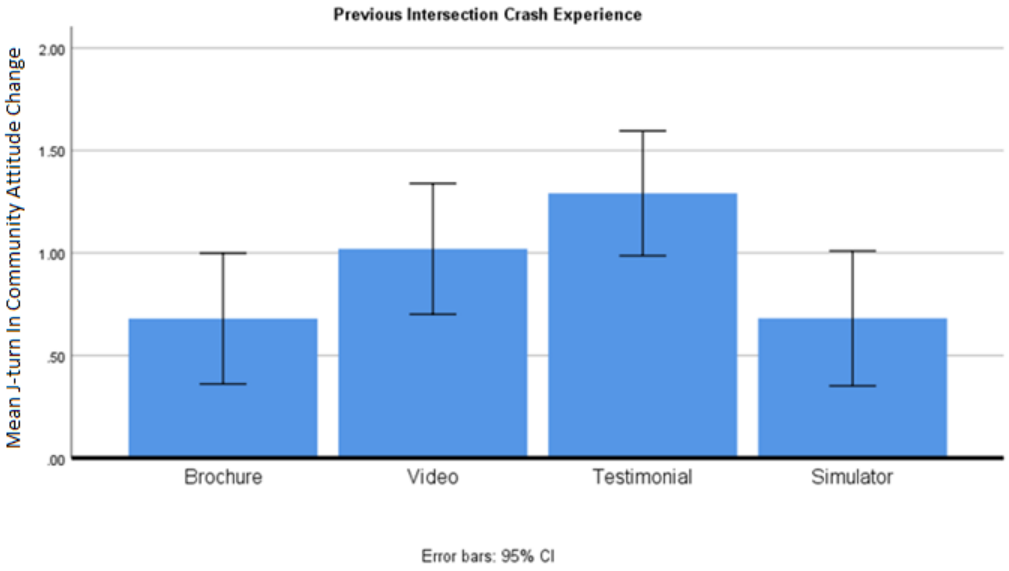

Figure 3.14 In Community Attitude change by presentation condition for drivers *with* intersection crash experience.

The results indicated a notable within-subject interaction effect of pre and post In-Community attitude scores with previous J-turn experience, $F(1, 216) = 5.832$, $p = .017$, see Figure 3.15. There was also a marginal interaction of pre and post attitude scores with previous intersection crash experience, $F(1, 216) = 2.099$, $p = .099$, see Figure 3.16.

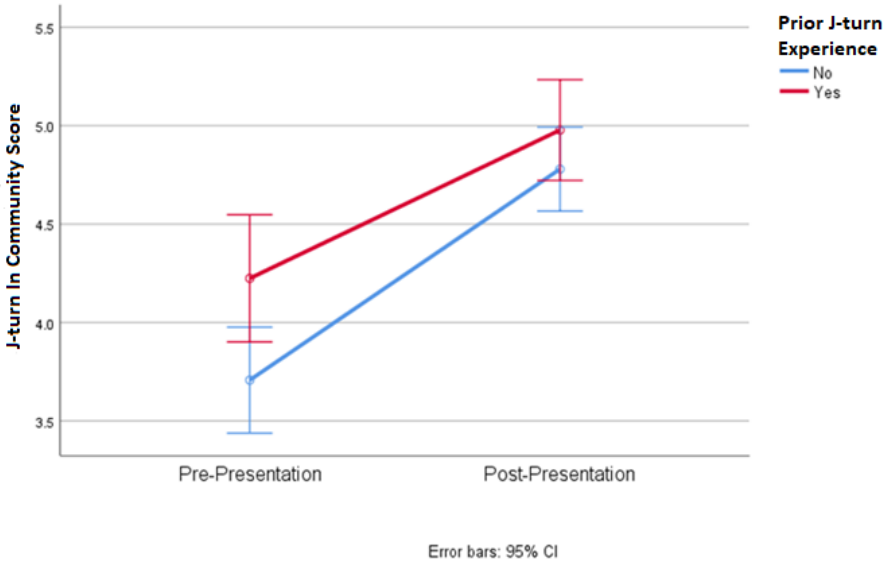

Figure 3.15 Pre and post attitude scores on J-turns in the Community looking at previous J-turn experience.

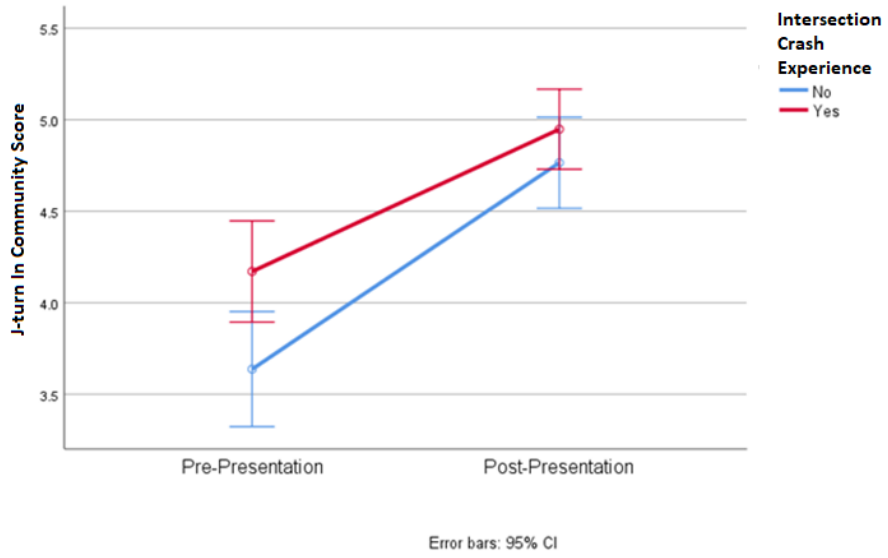

Figure 3.16 Pre and post attitude scores on J-turns in the Community looking at previous intersection crash experience.

Overall Attitude. When adding up all the scores for a summary measure of pre and post changes in attitude toward J-turns, the analyses remained consistent with the results presented earlier. One notable unique effect was found with the between-subjects variable of age, $F(2,257) = 4.341$, $p = .014$. Overall, younger adults (earlier than 35 years of age) were less favorable to the idea of J-turns compared to middle aged adults (35-54) and older adults (55+), when averaging across pre- and post- scores, see Figure 3.17.

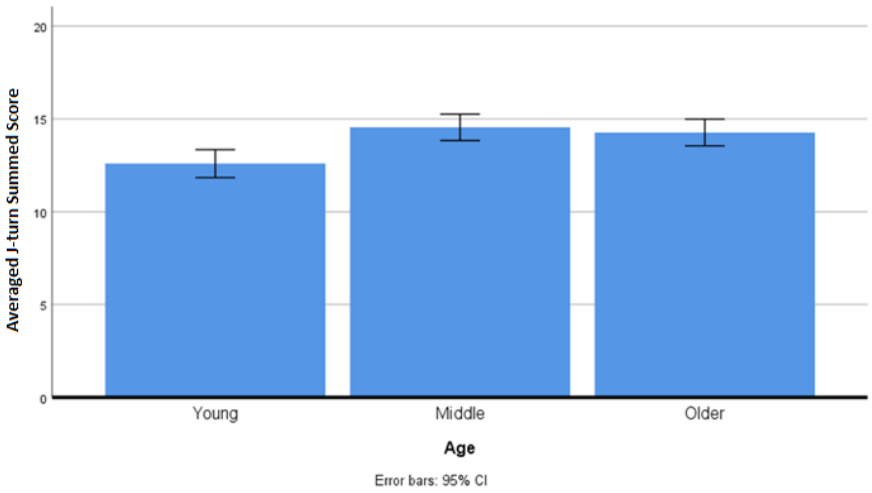

Figure 3.17 Averaged summed J-turn attitude scores across age groups.

3.2.2 Testimonial Study Results

3.2.2.1 Non-Video Predictors of Post-Treatment Attitude Change by Location

Non-video predictors of post J-turn attitudes were assessed with multiple linear regression. Results indicated that participants living in the seven-county metro, crash experience, less experience with roundabouts, support for roundabouts, and less experience with J-turns predicted the greatest post-test attitudes toward J-turns, Table 3.5.

Table 3.5 Regression Analysis Summary for Non-Video Predictors of Post-test Attitude Toward J-turns

Variable	*B*	SE *B*	*β*	*t*	*p*
Seven-County Metro	-1.655	.740	-.187	-2.237	.027
Crash Experience	.946	.694	.111	1.363	.175
Roundabout Experience	-.998	.752	-.111	-1.326	.187
Roundabout Support	.972	.248	.320	3.920	.000
J-turn Experience	-.874	.399	-.178	-2.191	.030

Note: R^2 = .17, p < .01. Seven-County Metro 0 = Yes, 1 = No and Crash Experience 0 = No and 1 = Yes.

3.2.2.2 Video Predictors of Attitude Change

Given that residence in the seven-county metro area appears to predict the post attitude score on J-turns, a portion of the following analyses on the characteristics of the videos and their impact on

attitude scores will be separated into analyses for those living within the seven-county metro and those living outside of the seven-county metro.

Living in Seven County Metro. Regression analysis was conducted to determine which video rating predictors on attitude change scores for those living in the seven-county metro. Results indicated that pre-J-turn attitudes (β = -.642, *SE* = .066; $p < .001$), perception of the speaker (β = 1.354, *SE* = .379, $p = .001$), and transportation (i.e., immersion) (β = .953, *SE* = .361; $p = .010$) predicted post J-turn attitudes for those living in the seven-county metro.

Living Outside Seven County Metro. Regression analysis was used to determine which video rating predictors on attitude change scores for those living outside of the seven-county metro. Variables were excluded if they had a p-value greater than .05. Results indicated that predictors of attitude change for those living outside the seven-county metro were pre-J-turn attitudes (β= -.412, *SE* = .090; $p < .001$) and cognitive response (β= 2.172, *SE* = .571; $p < .001$).

To further consider the impact of video for individuals living outside of the metro, because this group tended to have less support for J-turns, we considered cognitive processing average scores as a dependent measure. The cognitive processing questions are similar to pre and post attitude scores, but are asked for each video, allowing for a granular analysis. There was a significant difference for cognitive processing scores by video watched for those living outside of the seven-county metro $F(7,153) = 2.28$, $p = .031$. Video A (*M* = 3.22, *SD* = 1.14) and Video B (*M* = 3.21, *SD* = 1.34) showed the lowest cognitive processing scores. This suggests that after watching video A or video B, participants living outside of the seven-county metro were less likely to agree with building J-turns at high-risk intersections and were less likely to agree that building J-turns can improve the safety of the community.

These videos (A & B) also scored the lowest on cognitive response, as seen in Table 3.6. This further supports the regression analysis for participants living outside of the metro in that videos that elicited less cognitive response tended to produce less support for J-turns after viewing all of the testimonials.

VIDEO BY VIDEO BREAKDOWN

A MANOVA examined the effect of each testimonial video on the level of transportation, cognitive response, cognitive processing, perception of speaker, and perception of message. Using Pillai's trace, there was a significant effect of video on transportation, affective response, cognitive response, cognitive processing, perception of speaker, and perception of message, $V = .31$, $F(42, 2580) = 3.36$, $p < .01$.

Video G produced the highest level of transportation, perception of the message, and cognitive processing. For cognitive response, Video F and Video G scored the highest. Video F scored the highest for the perception of the speaker. Video E had the strongest positive affective response. See Table 3.6 for means and standard deviations for all videos and dependent variables.

Table 3.6 Means and standard deviations for dependent variables of transportation, affective response, cognitive response, cognitive processing, perception of speaker, and perception of message.

Video	*n*	Transportation *M*	Affective 1 Response* *M*	Cognitive Response *M*	Cognitive Processing *M*	Perception of Speaker *M*	Perception of Message *M*
Video A	59	3.94 (1.17)	3.20 (.83)	3.18 (.90)	3.53 (.94)	4.76 (1.27)	4.49 (1.65)
Video B	55	4.08 (1.43)	3.62 (.87)	3.46 (1.04)	3.69 (1.09)	5.64 (1.26)	5.24 (1.66)
Video C	54	4.25 (1.28)	3.74 (.87)	3.48 (1.02)	3.94 (1.07)	5.12 (1.33)	5.15 (1.55)
Video D	54	4.66 (1.09)	3.70 (.79)	3.62 (.85)	3.91 (.94)	4.94 (1.02)	4.85 (1.43)
Video E	53	4.27 (1.09)	**3.89** (.87)	3.49 (.93)	4.03 (1.02)	5.68 (.99)	5.66 (1.27)
Video F	52	4.41 (1.06)	3.67 (.81)	**3.78** (.73)	3.88 (1.01)	**5.83** (1.01)	5.52 (1.17)
Video G	55	**5.03** (1.10)	3.67 (.86)	**3.78** (.89)	**4.07** (.95)	5.47 (.97)	**5.70** (1.19)
Video H	56	4.23 (1.27)	3.52 (.85)	3.38 (.87)	3.98 (.96)	5.17 (1.12)	5.11 (1.45)

Note. *Affective 1 refers to the valence (positivity or negativity) of the emotional response. Affective 2, which is not included here, referred to the intensity of the emotional response. Cognitive response includes items 2, 3, and 4 only. Standard deviations in parentheses.

3.2.3 Large Sample Results

3.2.3.1 Non-Video Predictors of Post-J-turn Attitudes for Rural, Suburban and Urban

Regression analyses were conducted to determine which of the non-presentation variables predicted post-test attitudes toward J-turns for urban, suburban, and rural participants. For urban participants, personal involvement, i.e., the importance of safety for roadway designs (β = 1.336, *SE* = .320) and pretest attitudes (β = .246, *SE* = .070) were significant predictors of post-test attitudes. This suggests that for urban participants, post-test attitudes were predicted by those who valued the importance of safety in roadway designs and had more positive pretest J-turn attitudes.

For suburban participants, post-test attitudes were predicted by personal involvement (β = .544, *SE* = .250), pretest attitudes (β = .431, *SE* = .057), and support for roundabouts (*β*= .550, *SE* = .139). This suggests that for suburban participants, post-test attitudes were predicted by those who valued the importance of safety in roadway design, initial attitudes toward J-turns, and support for roundabouts.

Lastly, significant predictors for rural participant post-test attitudes included personal involvement (β= 1.016, *SE* = .262), pretest attitudes (β= .558, *SE* = .057) support for roundabouts (β= .540, *SE* = .116) and age (β= -.064, *SE* = .013). This suggests that for rural participants, predictors of post-test attitude change were for those who valued the importance of safety in roadway designs, had more positive pretest attitudes toward J-turns, greater support for roundabouts, and were younger in age.

Attitude Change Scores, Condition, and Urban, Suburban and Rural Participants. A factorial ANCOVA was conducted to examine city type (i.e., urban, suburban, or rural) and condition on participant attitude change scores, while controlling for participant pre-J-turn attitudes. There was a significant interaction between condition and city type on overall attitude change, $F(6,389) = 3.62$, $p = .002$. For rural participants, the simulation produced the greatest attitude change ($M = 3.75$, $SD = 3.01$). For urban participants, the informational video ($M = 4.77$, $SD = 3.46$) and the PowerPoint ($M = 3.60$, $SD = 3.17$) produced the greatest attitude change. For suburban participants, the narrative storytelling ($M = 3.90$, $SD = 3.58$) resulted in the greatest attitude change.

Bonferroni post hoc tests revealed that there was a significant difference between urban and rural participants for the informational video, with urban participants showing stronger post-J-turn attitudes ($p = .009$). For the PowerPoint condition, Bonferroni post hoc tests revealed that there was a significant difference in post-J-turn attitudes for urban participants ($p = .009$) compared to suburban participants, see Figure 3.18.

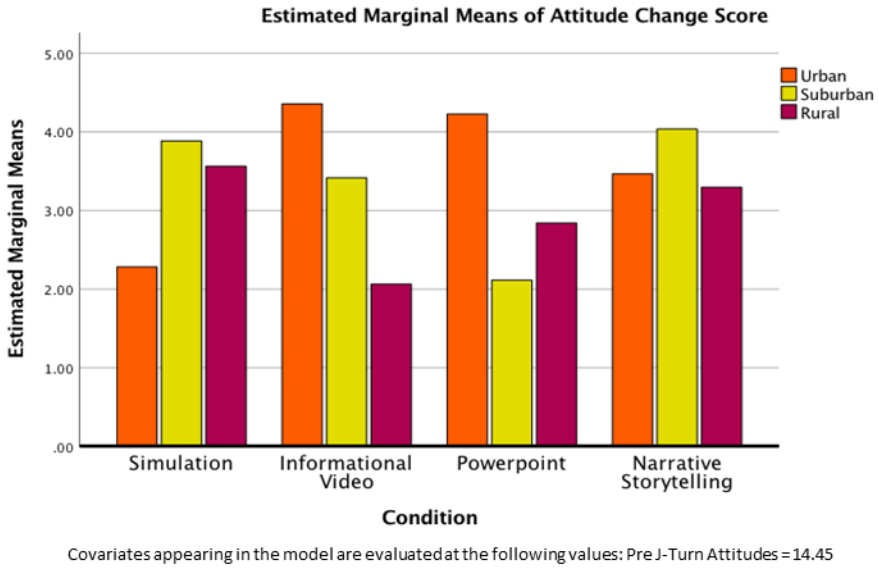

Figure 3.18 Bar graph of J-turn attitude change scores by treatment condition and city type

Presentation Breakdown. A MANOVA was conducted to determine the effect of presentation type on the presentation variables (i.e., transportation, cognitive response, perception of presentation, and perception of message). Using Pillai's trace, there was a significant effect of presentation type on transportation, cognitive response, perception of message, and perception of presentation, $V = .103$, $F(3, 399) = 3.55$, $p < .01$.

The simulation condition resulted in the highest level of transportation ($M = 5.85$, $SD = .91$) and perception of the presentation ($M = 5.96$, $SD = 1.15$), while the narrative storytelling condition resulted in the strongest perception of the message ($M = 5.90$, $SD = 1.26$). The PowerPoint condition produced the greatest cognitive response ($M = 3.86$, $SD = .61$). See Table 3.3 for means and standard deviations

for all conditions and dependent variables. Bonferroni post hoc tests revealed the simulation condition produced significantly higher levels of transportation compared to the PowerPoint (p = .042) and the testimonial (p = .018) conditions.

Table 3.7 Means and Standard Deviations for Transportation, Cognitive Response, Perception of Message, and Perception of Presentation by Condition.

		Transportation	Cognitive Response	Perception of Message	Perception of Presentation
Condition	*n*	*M*	*M*	*M*	*M*
Simulation	91	**5.85** (.91)	3.68 (.58)	5.81 (1.18)	**5.96** (1.15)
Informational Video	109	5.54 (1.13)	3.73 (.62)	5.70 (1.43)	5.58 (1.44)
PowerPoint	104	5.44 (1.05)	**3.86** (.61)	5.62 (1.48)	5.46 (1.39)
Narrative Storytelling	99	5.40 (1.03)	3.73 (.59)	**5.90** (1.26)	5.58 (1.47)

Note. Transportation, perception of message, and perception of presentation on 7-point scales. Cognitive response on 5-point scale. Standard deviations in parentheses.

3.3 DISCUSSION

The overall goal of this work was to evaluate the effectiveness of different persuasive presentation methods to increase attitudes and support for J-turns by measuring their receptiveness among geographically diverse communities to increase buy-in, support, and resiliency. The outcome of this work resulted in identifying multiple persuasive presentation modalities that may be used to improve attitudes toward novel roadway designs that are applicable to geographically diverse population groups (i.e., urban, suburban, rural). Across all studies, overall attitudes toward J-turns significantly improved from pre- to post-treatment, suggesting that there are multiple effective presentation modalities that may effectively increase buy-in and support for J-turns at the community level. Interestingly, across all three research activities, participants reported higher support for willingness to drive on J-turns over supporting J-turns to be placed in their community and that J-turns were a good idea, suggesting that participants are more likely to drive on J-turns but may be hesitant to introduce them into their own communities. Additionally, other factors such as greater support for roundabouts were found to consistently predict stronger support for J-turns in the Testimonial Study and Large Sample Study.

The key findings from the State Fair Study highlighted several factors that may predispose individuals to be more or less accepting of J-turns initially and may influence how impactful educational messages may be in accepting its design as a safety benefit. Urban participants tended to be more accepting of J-turns than rural participants. Young drivers were less accepting of J-turns than middle aged or older participants. Additionally, participants with prior J-turn experience and those with intersection crash experience tended to be more accepting overall of the J-turns. All presentation methods were generally effective at improving attitudes toward J-turns.

The key findings from the testimonial study suggested that attitudes increased after viewing any of the eight testimonial videos. Additionally, there were also observable differences in predictors of attitude

change between participants living in and outside of the seven-county metro of the testimonial videos. Participants living outside of the metro who thought about how much J-turns could affect their own lives and the consequences of a traditional high-risk intersection were more likely to have greater attitude change. On the other hand, participants who lived inside the seven-county metro were more likely to be swayed when watching a testimonial that immersed them in the story and contained a speaker that possessed key attributes identified in previous research (i.e., credible, trustworthy, knowledgeable). The findings are in line with previous research suggesting that attitude change may be due to its ability to immerse the viewer in the story, make the viewer think about content related to the story, or because the speaker in the story was perceived to be likable and trustworthy (Green & Brock 2000; Banerjee & Green, 2012; Chaiken & Eagly, 1983).

Analysis of video evaluation variables revealed that three testimonials resulted in the greatest response from the viewers and were classified as having desirable message characteristics. Specifically, the informational/personal story shared by the middle-aged, sales general manager (i.e., Video E) had the most positive emotional response from viewers, the state patrol's informational video (i.e., Video F) made participants think about the content in the video and contained a speaker that possessed key attributes (e.g., likable, trustworthy, credible), and the older parent/driver's personal story and opinion (i.e., Video G) not only made participants think about the content, but immersed viewers in the story, and had a message that was perceived to be strong and carefully thought out.

Findings from the large sample study suggested that all four presentation methods increased attitudes toward J-turns, especially for those who reported lower initial support that J-turns are a good idea, willingness to drive on J-turns, and support for J-turns to be placed in the community. Moreover, the degree to which viewers felt safety was an important component of roadway design (i.e., level of personal involvement) influenced attitudes toward J-turns, suggesting that persuasive messaging may be more powerful when the story is personally relevant to the viewer because it enhances the importance of the message (Petty & Cacioppo, 1979; Braverman, 2008).

Furthermore, observed differences in presentation method characteristics suggested that messaging strategies may be specific to the geographic region. Urban areas showed the greatest attitude change after watching the informational video or PowerPoint presentation, suggesting they were most receptive to a presentation that elicited thoughts about the content (i.e., message-relevant thinking) discussed in the presentation when indicating their attitudes toward J-turns. Residents of suburban areas showed the greatest attitude change after viewing the testimonials or participating in the simulation presentations, suggesting they may be most receptive to a presentation method that has a good message (i.e., is convincing, carefully throughout), one that makes them feel absorbed or immersed in the experience and/or prompts message-relevant thinking about the components of the presentation. Finally, for rural residents, attitude change was the greatest after the simulation or testimonial presentations, suggesting that attitudes may be most influenced by a message that immerses the viewer, is perceived to be unbiased and trustworthy, and/or contains a message that is carefully thought out and fairly evaluates the evidence.

CHAPTER 4: MESSAGES TO THE PUBLIC

After identifying a set of effective educational and persuasive messaging materials to improve attitudes toward J-turns, the materials were packaged into a short presentation that consisted of an informational, educational, and narrative storytelling (i.e., testimonial) component. The packaged presentation was shared with J-turn stakeholders from across the state of Minnesota to assess their influence on attitudes toward J-turns and to assess the degree to which stakeholders felt the materials would resonate with their constituents. Next, the presentation materials were presented to community members of Two Harbors, Minnesota at a virtual community engagement demonstration hosted by MnDOT personnel to determine how well the materials would resonate with communities scheduled to receive upcoming J-turn road treatments.

4.1 METHODS

4.1.1 Stakeholder Study

In the stakeholder study, an online study examined the effectiveness of presentation methods in securing stakeholder support for J-turns. Metrics used from previous research activities were used in the stakeholder study. Stakeholders completed an online survey and corresponding interviews to provide additional feedback on the materials of the survey, including the overall effectiveness of the materials and discussed current challenges in how the state communicates about roadway changes. The outcome suggested that the presentation materials increased overall attitudes toward J-turns and increased stakeholders' confidence in their ability to communicate about J-turns to their constituents.

4.1.2 Pilot Study

A pilot test was conducted to ensure the appropriateness of timing, content, and questions. The pilot participant was selected to represent a prototypical city council member representing a rural community from out of state to avoid disseminating the educational materials within the state of Minnesota prior to final modifications. Following the set protocol, a debrief interview was conducted to allow the pilot participant to provide candid feedback on the experience and provide suggestions on how the presentation or questions may be improved. Modifications were made based on the findings of the test.

4.1.3 Study Recruitment

Stakeholders were sampled from each district of the state. Recruitment consisted of email requests and phone calls to state legislative representatives, city council members, city mayors, city council, public works directors, community engagement members, and city administrative staff. Recruitment efforts focused on sampling stakeholders from a city (e.g., city manager), county (e.g., county board member), and state (e.g., state legislator) level from each district. In total, participants were recruited from seven of the eight MnDOT Districts. See Table 4.1

Table 4.1 Participant sampled locations by MnDOT district.

MnDOT District	Sampled Locations
District 1	Pine City, Hermantown, Rice Lake City, Cloquet
District 3	Brainerd, Little Falls, Staples, Sartell, Elk River
District 4	Morris, Otter Tail County, Perham, Fergus Falls
Metro District	Scandia, Farmington
District 6	Faribault, Zumbrota, Lanesboro
District 7	Wells, Fairmont
District 8	Hutchinson, Clarkfield

4.1.3.1 Participants

In total, 308 participants were recruited to participate from across the state of Minnesota. Of those recruited to participate, a total of 24 participants completed the study. For gender, there were 6 females (25%) and 18 males (75%). The average age was 45.25 (*SD* = 9.21), with a range between 31 to 68 years of age and a median age of 44.5. For education, 3 (12.5%) reported having an associate degree, three (12.5%) had some college, no degree, nine (37.5%) had a bachelor's degree, eight (33.3%) had a graduate or professional degree, and one (4.2%) reported having a trade degree. The majority of participants (20 or 83.3%) reported their role as a stakeholder was at the city level, while two (8.3%) were stakeholders at the county level, and two (8.3%) at the state level. Specifically, stakeholder roles included City Council Members (n = 3), Community Development Director (n = 1), Community Engagement Director (n = 1), Committee Chair of Public Works (n = 1), Mayors (n = 3), Public Works Directors (n = 4), City administrators (n = 7), and City Managers (n = 2). For self-reported participant location, five (20.8%) reported living in urban areas, six (25%) reported living in suburban areas, and 13 (54.2%) reported living in rural areas.

4.1.4 Materials

An online survey was created to provide a basic introduction to Restricted Crossing U-Turn intersections (J-turns), assess initial attitudes regarding J-turns, present information on J-turns, measure the perception of the presentation, measure post-treatment attitudes regarding J-turns, and finally measure attitudes regarding roundabouts. The same measures of driver behavior, J-turn attitudes, and personal involvement used in the previous research activities were used in the stakeholder study. See Appendix C for final materials.

Testimonial Videos. Three testimonial videos that produced the greatest attitude change and contained speaker attributes that resulted in significant attitude changes in the testimonial study and large sample study were selected for the stakeholder sample. The first video was a personal story and opinion that

consisted of a speaker who was an older adult, male parent from Wilmar, MN. The second video was a middle-aged adult, vehicle sales general manager from St. Peter, MN. The third video was an older adult male who was a state trooper from the Shakopee region, Figure 4.1.

Figure 4.1 Screenshots of testimonial videos used in the stakeholder study.

Perception of Presentation and Perception of Message. Three items were adapted to assess the participant perception of the speaker in each video. With positive poles: unbiased, credible, and trustworthy on a 7-point response set. Additionally, three items were modified using 7-point response scales to rate the strength of the message, how carefully thought out the message was, and how convincing the message was.

Presentation Experience. Two items assessed participants' presentation experience including how much the participant enjoyed the presentation and whether the participant would recommend the presentation to others.

Post Presentation Slides. Two slides providing benefit information about J-turns with information on cost savings and statistics on serious injury and fatal crashes were presented to participants after viewing the testimonial videos.

Interview Questions. Stakeholders were asked to provide additional feedback about J-turns that they felt could not be conveyed in the survey, feedback about the presentation materials, including their effectiveness and applicability across other types of roadway designs. Additionally, stakeholders were asked to identify any failures in current communication strategies when approaching communities about roadway change and were invited to share any additional thoughts they had about J-turns.

4.1.5 Procedure

Participants completed the survey component online through Qualtrics and completed interview questions in either a live interview (i.e., synchronous) format over Zoom or provided written responses (i.e., asynchronous format) to open-ended interview questions through the online survey. All participants completed baseline measures, learned about J-turns, completed post-test measures, and then provided feedback on the presented materials via live interviews or through written response.

4.2 RESULTS

Frequencies and percentages were calculated for participant familiarity with J-turns as well as participant crash experiences. A greater percentage of participants had heard of J-turns and were

somewhat familiar (37.9%), while 33.3% of participants had never crossed a J-turn. For crash or near-miss experience, 12.5% reported a crash or near-miss experience greater than 10 years ago, 16.7% of participants had experienced a crash in the last 10 years, 37.5% had experienced a crash or near-miss experience in the past five years, and the remaining 33.3% had not had a crash or near-miss experience. The majority of participants reported no experience of someone close to them having a crash or near-miss experience (62.5%). See Table 4.2 and Table 4.3

Table 4.2 Frequencies and percentages of stakeholder familiarity and experience with J-turns

Variable	*n*	%
Familiarity with J-turns		
I have never heard of J-turns	3	12.5
I have heard of J-turns but am not very familiar	6	25.0
I have heard of J-turns and am somewhat familiar	9	37.9
I have heard or J-turns and am very familiar	6	25.0
Experience with J-turns		
I have never crossed a J-turn	8	33.3
I have crossed a J-turn once or twice	6	25.0
I occasionally cross J-turns	9	37.5
I frequently cross J-turns	1	4.2

Table 4.3 Frequencies and percentages of crash experience

Variable	*n*	%
Crash or near-miss experience		
No	8	33.3
Yes, in the last 5 years	9	37.5
Yes, in the last 10 years	4	16.7
Yes, greater than 10 years ago	3	12.5
Someone close in serious or fatal crash		
No	15	62.5
Yes, in the last 5 years	2	8.3
Yes, in the last 10 years	3	12.5
Yes, greater than 10 years ago	3	12.5
Unsure	1	4.2

Attitudes toward J-turns. Means and standard deviations were calculated for participant scores on pretest and post J-turn attitude items, as well as summed pretest and post-test attitude scores. See Table 4.4. Next, paired samples t-test were computed to determine if there were meaningful differences

between pre- and post-test J-turn attitudes. Results indicate that there was a significant difference between pre- and post-test attitudes in thinking J-turns are a good idea, $t(23) = -2.996$, $p = .006$, and a significant difference in attitude change for supporting J-turns to be placed in the community, $t(23) = -2.846$, $p = .009$. However, there was not a significant difference in participant willingness to drive on J-turns between pre- and post-test attitude scores. Participants' pretest attitudes for willingness to drive on J-turns was high ($M = 6.29$, $SD = .96$) and remained similarly high within their post-test attitudes ($M = 6.33$, $SD = .82$). Finally, there were significant differences in pre- to post-test attitude scores, $t(23) = -3.238$, $p = .004$, suggesting that attitudes toward J-turns significantly improved after viewing the presentation materials.

Table 4.4 Pre- and post-J-turn attitude scores

	Pre J-turn Attitude	Post J-turn Attitude
	M	*M*
J-turns are good idea	5.21 (1.87)	5.88 (1.33)
Willing to drive on J-turn	6.29 (.96)	6.33 (.82)
Support J-turn in community	4.67 (2.26)	5.08 (2.21)
J-turn Attitude Score	16.17 (4.68)	17.29 (4.12)

Additionally, participants reported increased confidence from pretest ($M = 4.75$, $SD = 1.62$) to post-test scores ($M = 5.17$, $SD = 1.34$) in their ability to educate their constituents about J-turns, their benefits, and efficacy after viewing the presentation materials. This difference was marginally significant, $t(23) = -1.792$, $p = .086$, but had a medium effect size (Cohen's d = 0.369).

When considering the average presentation enjoyment values, 8.3% reported they "loved it", 29.2% reported the presentation materials as "enjoyable", half the participants rated the materials as "fine", while the remaining indicated the presentation was "so-so" (25%) or dull (8.3%). When asked if they would recommend the presentation materials to others, 20.8% indicated they would definitely recommend the materials, 41.7% said they would probably recommend the materials, 16.7% said they possibly would recommend, and the remaining said they were neutral (16.7%) or possibly may not (4.2%) recommend the presentation materials.

4.2.1 Association of Driver Behavior Variables, Video Variables and Post-Presentation Attitudes

Correlations were calculated for driving behavior variables and the presentation variables with post-test J-turn attitudes. For the driving behavior variables, there were significant positive correlations between the importance of safety in roadway designs and attitudes toward J-turns and support for roundabouts and post-test attitudes toward J-turns. This suggests that those who hold more favorable attitudes toward safety in the design of roadways, as well as more favorable support for roundabouts, showed more supportive attitudes toward J-turns. Additionally, all presentation variables had significant and positive correlations with post-test J-turn attitudes. This suggests that when presentation materials are

perceived as unbiased, credible, and trustworthy are more likely to be associated with greater support for J-turns. Finally, all message variables showed positive and significant correlations with post-test J-turn attitudes. This suggests that when messages that are perceived to have a strong argument, convincing and fairly evaluated evidence, and are carefully thought out are more likely to be associated with stronger attitudes toward J-turns.

Table 4.5 Driving and Presentation Variable Means, Standard Deviations and Correlations with Post-J-turn Attitudes

Variable	*M*	*SD*	*r*
Safety in Roadway Design	4.17	1.05	.551**
Happiness with MN Roadways	3.58	.65	.208
Roundabout Support	5.71	2.16	.680**
Roundabout Experience	3.63	.49	.056
Presentation Variables			
Unbiased	4.38	2.04	.504*
Credibility	6.13	.95	.614**
Trustworthy	5.92	1.40	.589**
Message Variables			
Argument strength	6.13	.74	.756**
Carefully thought out	6.00	1.11	.545**
Convincing	5.92	1.06	.732**
Fairly evaluated evidence	5.71	1.04	.739**

Note: Safety in roadway design and happiness with roadways use a 5-point response set. All other variables use a 7-point response set. $^{**}p < .001$, $^{*}p < .05$.

4.2.2 Interview Feedback

Overall Feedback. Participants were asked to provide any additional feedback on J-turns that they felt they could not otherwise indicate in the survey. Several participants reported that they thought it was useful to include benefits of J-turns and were glad to see statistical information on cost comparisons (i.e., J-turn compared to traditional highway) as well as safety statistics (i.e., reduced crash rates) in the presentation materials. Additionally, many participants reported it would be helpful to have information about navigating a J-turn with farm equipment, for semi-trucks and oversized loads. One testimonial video included in the presentation materials included information about semi-truck drivers navigating the J-turn was well-received by many participants. At the same time, several participants felt the content had not fully convinced them that a J-turn would be a good fit for communities with many commercial vehicles and semi-trucks. Some participants reported that they had never seen a J-turn prior to viewing the presentation materials, but were familiar with other roadway designs (e.g., roundabouts, cloverleafs), and indicated that they felt the presentation materials were educational to the point that they understand J-turns and their benefits. Other participants expressed concern about how pedestrian

needs may be impacted by J-turns, such as their ability to safely cross the roadway. Several reported feeling frustrated that the focus of roadway design changes tended to be on truck and automobile safety, particularly in towns that were focused on prioritizing pedestrian safety and needs.

Feedback on Presentation Materials. When asked to provide feedback on the presentation materials, some participants reported that they thought the materials were well thought out, valuable, informative, and effectively got the message across to the audience. Additionally, there was generally positive and receptive feedback regarding the three testimonial videos, with participants indicating that they thought the variety of speakers as well as the content presented in the messages was effective and credible. Participants noted that it would be useful to provide information on how to navigate the J-turn (e.g., when to pull out, waiting for lanes to clear), especially for those who had not crossed a J-turn. However, others reported that they thought the materials were biased and felt they were only hearing one side of the story (i.e., benefits of J-turns). Additionally, several participants reported that they felt engineers were primarily responsible for the decision-making regarding roadway changes and that roadway changes often felt more like an announcement rather than a collaborative approach.

How well materials would resonate with constituents. When asked how well the materials would resonate with their constituents, some participants indicated that the materials would resonate very well, while others did not think the materials would be useful. Specifically, those in support of the materials felt that the materials would provide a good educational component, felt it would be easily understood, was short and to the point, and thought the variety of the materials (e.g., statistics, testimonial videos) would be an effective method of communication. Additionally, several participants noted that it would be important to conduct public outreach prior to implementing J-turns and emphasized the importance of being transparent with the community. Although participants indicated that their constituents may initially have some resistance toward J-turns, they felt that the materials would be convincing and effective in communicating their benefits.

Conversely, those who did not think the materials would resonate with their constituents felt that the materials were simply not applicable to their constituents, felt their constituents would not pay attention to the materials, or that they generally were not open nor accepting of changes. Additionally, participants reported they felt that the materials failed to address the needs of pedestrian safety, and how J-turns might impact the use of non-motorized vehicles as well as the environment.

4.2.3 Efficacy of messaging on communicating other road designs

Overall, many participants felt that this type of messaging strategy would be helpful for communicating other types of road designs. Specifically, participants noted that the presentation of visual information was useful for educating participants about a new design they had not previously heard about and thought this type of light education would be effective in communicating with their constituents.

The most consistent piece of feedback received from participants was related to the challenge of communicating with community members. One participant recited a notable quote that the “issue with communication is the illusion that it has occurred,” noting that stakeholders and other leaders often

underestimate the amount of effort required to effectively communicate with community members. The issue of communication is particularly relevant given the diverse use of news outlets (e.g., social media, radio, television) and competing for the attention of community members in the age of information overload. Participants reported it was particularly difficult to reach a broad and diverse audience due to differences in the type as well as the number of news outlets used by their constituents. Specifically, participants were unsure how to effectively communicate messages with different age groups (e.g., younger people vs. older people), which platforms would be the most effective in getting out a clear, concise message. Further, participants noted that there was a challenge in being able to effectively capture their constituents' attention in a manner that was both educational, yet short and to the point.

Finally, several participants reported that they often felt that communications about roadway design changes were given as an "announcement" such that the decision to implement the design had been predetermined by the engineers and members of the state. Therefore, they felt that it was important to be transparent with the public, allow them to share their thoughts and opinions regarding roadway changes and provide educational information to clarify any points of confusion to help community members better understand the decision-making process behind upcoming roadway changes.

4.3 DISCUSSION

The findings from the stakeholder study suggest that the presentation materials effectively improved stakeholder attitudes and support for J-turns, as well as their confidence to effectively communicate with constituents about roadway change. Additionally, the degree to which stakeholders felt safety was important in roadway designs and higher support for roundabouts were found to be associated with more positive attitudes toward J-turns, which is consistent with findings from the previous research activities.

The combination of materials used in the presentation of this study appears to satisfy most of the needs and wants of stakeholders sampled in this study. Customization of the content may be necessary based on the unique needs of the community (e.g., pedestrian concerns, farm activities, etc.). The length of the materials may not satisfy the attentional constraints conveyed by many of the stakeholders in seeking to reach their constituents.

Local stakeholders expressed a consistent concern with their ability to adequately communicate with constituents in a timely manner. As a shared experience, competing streams of information, along with a fast news cycle, limits their ability to convey safety information in advance of implementation projects. This suggests the importance of practical education and communication efforts regarding J-turns (i.e., in advance of project announcements) to help expedite communication processes at locations once they have been selected for implementation.

4.4 COMMUNITY ENGAGEMENT DEMONSTRATION

Because local stakeholders expressed concern with their ability to inadequately communicate with constituents in a timely manner, the goal of the community engagement project was to examine the effectiveness and receptiveness of an educational community demonstration on J-turns in a community that was selected for implementation of J-turns.

Community members of Two Harbors, Minnesota were provided with an educational and informational session about upcoming roadway treatments (i.e., J-turns/RCIs) planned in their community. Notably, the RCI, i.e., reduced conflict intersection terminology, rather than J-turn, was selected by the local engineering team for this community engagement and will be referenced accordingly in this section. Based on the findings in previous tasks on differences in geographic location and the effectiveness of persuasive messaging materials, a presentation was developed using a mixed-methods messaging approach including informational slides and three testimonial videos. The community engagement demonstration was hosted through a Webinar in collaboration with MnDOT representatives of the Highway 61 Intersection Improvement project in December 2021. The outcome of this work demonstrated the importance of understanding how effective persuasive messaging may in part depend on understanding the characteristics of the audience.

4.4.1 Materials

A slide deck was created in PowerPoint for the virtual community engagement event. The slide deck consisted of ten informational slides on RCIs and their benefits and three testimonial videos.

Informational Slides. Ten slides were created to present information on RCIs and their benefits. These slides were developed through a user-centered, iterative design process through a series of studies conducted by the research team with Minnesota drivers and stakeholders, see Figure 4.2. The slide contents included information regarding the need for J-turns (referenced as RCIs), their safety and cost benefits, and how to navigate through them. See Appendix E.

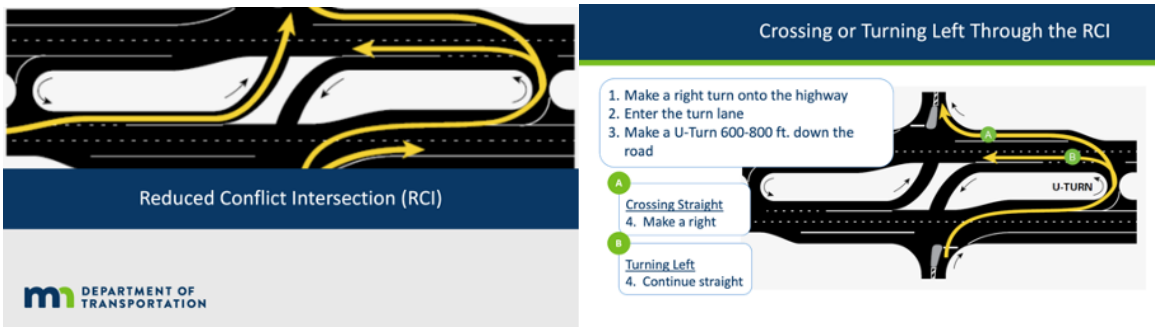

Figure 4.2 Screenshots of informational slides presented at the community engagement event.

Testimonial Videos. The research team engaged in discussion with the project management team to determine which community members may have the greatest concerns regarding the proposed Two Harbors' RCI and attempt to match these concerns with the stories available in the library of testimonials previously tested. The project management team indicated that business owners are expected to be among those with the greatest concerns. Additionally, the parent testimonial from Wilmar, MN, which has previously received positive feedback from respondents, was discussed to focus on a particular RCI layout that may not be applicable to the proposed design in Two Harbors, MN.

Following these considerations, three testimonial videos were selected for the community engagement demonstration. The first video (1 minute and 25 seconds) was an informational video that consisted of a middle-aged male adult who was a grocery store owner in Jordan, MN. The second video (1 minute and 29 seconds) was an informational and personal opinion video that consisted of a middle-aged male adult who was a vehicle sales manager from St. Peter, MN. The third video (1 minute and 41 seconds) was an informational video that consisted of an older adult male who was a state trooper from the Shakopee region.

4.5 OVERVIEW OF COMMUNITY ENGAGEMENT DEMONSTRATION

The community engagement demonstration was hosted on an online webinar on Highway 61 Intersection Improvements in December 2021 in collaboration with MnDOT personnel. A total of five community members joined the live webinar. Next, the members of the research team began with team introductions and provided an overview of their research role with RCIs. To follow, the research team presented the informational slides and the testimonial videos and invited community members to ask questions or share any feedback they had about the presentation materials. Next, MnDOT representatives from the Highway 61 Intersection Improvements project provided a detailed presentation on the engineering and design of the proposed RCIs. Finally, community members were asked to share any additional feedback on presentation materials in the community engagement demonstration. The webinar lasted for approximately 90 minutes and was made available to community members to access on the project website.

Survey. The research team presented a web link (in both the slide and webinar chat function) and associated QR code on the presentation slides to invite attendees to complete both a pre- and post-survey at the start and end of the presentation. The survey was designed to assess attendees' knowledge and attitudes of RCI to determine if any shifts in these metrics occurred following the presentation. Of the five attendees, only one completed both the pre- and post-survey. The data from this respondent cannot be shared due to the low numbers of the total attendees and the research team's inability to aggregate the data. Notably, the individual's responses did not shift following the presentation and no comments were submitted in the open entry field.

4.6 OVERALL DISCUSSION

After watching the presentation materials, stakeholders' attitudes toward RCIs not only increased, but they reported feeling more confident in their ability to educate their constituents about the benefits and efficacy of RCIs in the community. Moreover, using a mixed-methods messaging approach to educate stakeholders about RCIs was perceived to be unbiased, well-thought out, and to have evaluated the evidence fairly (about RCIs), which was also associated with more positive attitudes about RCIs.

Overall, the community engagement demonstration was well received by members of the audience. The outcome of this work provided support for the use of a mixed-method approach to communicate about novel roadway design changes to members of the community. The lack of resistance to the presented materials in the community demonstration from rural residents further supports the use of mixed-messaging efforts to communicate roadway implementation projects with the public. Furthermore, the findings from this work suggest that the consideration of the audience characteristics (e.g., geographic location) in the customization of educational and informational messaging materials is an effective method for increasing acceptance and buy-in for novel roadway designs. Taken together, effective messaging materials are those that consist of informational, educational, and experiential components.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

The goal of this work was to establish reproducible methods to engage and educate stakeholders and members of the community about upcoming roadway treatments to improve attitudes and community support toward their implementation. The findings from this work demonstrate the importance of the role of proactive educational programs and community initiatives in promoting the acceptance and buy-in toward novel roadway treatments, such as J-turns, for both novice and experienced drivers and across varying geographic locations in the state (i.e., urban, suburban, and rural areas).

The simulation study suggests that although J-turns may initially be confusing or frustrating to navigate for novice J-turn drivers and result in more driving errors, repeated use following implementation can quickly improve decision-making, reduce the amount of physical driver head movements (i.e., looking right and left) while navigating an intersection by focusing on traffic one direction at a time, and makes them seem less stressful and easier to navigate compared to conventional intersections. While the simulation study reveals few differences in performance based on the level of signage, the results suggest that the moderate signage condition may slightly outperform the minimum and full signage condition. Drivers are found to have slight improvements in efficiency in navigating the J-turn in the moderate signage condition, suggesting that minimum signage provides insufficient information for decision-making, but full signage may provide too much information to support decision-making. Further, participants often reported that they did not notice the differences between the signage conditions, suggesting that the additional costs in maintaining the excess signage of the full signage condition would not only not support better efficiency but would also not necessarily even result in a noticeable change for most drivers. Redirecting these funds to support increased driver education and outreach could result in greater gains for performance improvements than would excess signage at J-turns.

Findings from the State Fair, Testimonial, and Large Sample studies show that different forms of persuasive messaging techniques (i.e., testimonials and informational videos) can effectively improve public attitudes toward J-turns. Additionally, findings from these studies suggest that attitude change may be dependent on other fixed and random factors, including geographic location, attitudes toward other nontraditional roadway designs (i.e., roundabouts), and whether these topics are perceived to be personally relevant to the viewer. Importantly, the findings from this work show the consistent efficacy of using storytelling (i.e., testimonials) to influence viewer attitudes toward attitudinally resistant topics, such as J-turns. One reason for their persuasive power may be due to the ability to immerse (i.e., transport) the viewer into the message of the story. Individuals who are transported into a narrative world are likely to change their real-world beliefs in response to information, claims, or events in a story (Green, 2006).

J-turn attitude changes across the persuasive messaging studies and within the stakeholder study were consistently linked to the degree to which individuals report that roadway safety is important to them. The amount of involvement individuals have in roadway safety contributes to the persuasive impact of a narrative story (i.e., testimonial) and attitude change is a result of the degree to which the viewer thinks about the message arguments (Bae, 2008). This suggests the importance of engaging the public in a

meaningful way about how roadway safety impacts their community, their family, and themselves. In application, J-turn, or other nontraditional traffic treatment presentation materials should be made to help viewers think about the importance of the benefits of the implementation (e.g., J-turn) which should, in turn, increase the likelihood that they will show improved attitudes toward the implementation.

5.1 LIMITATIONS

There may have been limitations in the driving simulation study with low study power to detect an actual effect of specific signage levels (i.e., full, moderate, and minimum) on first-time exposure driving performance. Of the 44 participants who participated in the study, only a third of the participants were able to experience one of the signage levels for their first exposure (i.e., the other signage conditions were experienced in the second or third exposure drive). The largest effects of the study were observed in the repeated exposure to the J-turn, independent of signage condition. Future studies may need to increase the sample size to increase the study power to ensure no significant differences exist among the three signage levels or may require a reduction to only two signage levels to increase the proportion of participants who could be exposed to each level for their first exposure.

The results of the State Fair, Testimonial, and Large Sample studies all tended to find increased support for J-turns following most presentation forms. However, some participants may have responded differently to questions, such as “Would you be supportive of a J-turn Intersection to be placed in your community?” if it were not hypothetical, and an actual J-turn was being proposed for their community. Thus, these studies may overestimate the level of community support that the persuasive materials evaluated may receive when used in practice. Notably, the community engagement demonstration with Two Harbors appears to have been a successful engagement given that no vocal or written opposition was received from community members in attendance or asynchronously. However, the overall attendance was low, and COVID-19 public health constraints may have limited typical engagement from community members who do not have Internet access or do not prefer to engage in this manner. Additionally, this particularly proposed installation may not have included the specific factors (e.g., suboptimal detour during construction) that resulted in community pushback in other areas of the state. Future research could continue to examine how well the use of persuasive communication in actual community engagement activities compares to comparable engagement without such materials.

5.2 RECOMMENDATIONS

The general steps recommended for implementation were to prioritize outreach and persuasion engagement methods prior to proposing a J-turn. The findings from this work suggested several recommendations to maximize the effectiveness of mixed messaging strategies to communicate upcoming novel roadway treatments across the state. Most tested methods were found to be effective, although some approaches could be more effective for certain demographics. First, it was recommended prior to communicating messages for upcoming roadway treatments, the communication team should understand the demographics of the audience and customize their communication

messages accordingly. Specifically, careful consideration should be given to geographical location in the customization of message delivery. For example, testimonials were generally effective across most demographics, but rural participants in the testimonial study were more persuaded by testimonial narratives that led them to think about the rationale for installing a J-turn, whereas participants from urban areas were more likely to pay attention to the qualifications of the messenger. Here are some core steps of persuasive messages and signage for J-turns:

1. It is recommended that a mixed-method messaging strategy be used when communicating upcoming roadway changes. This mixed-method strategy should include a combination of testimonials and educational materials, such as statistical comparison rates and an overview of the proposed roadway design, including its benefits.
2. Find ways to get people to be personally involved (e.g., reflecting on a loved one or themselves being involved in a crash or near-miss crash at an intersection) prior to presenting educational information.
3. For less-invested individuals, shorter persuasive messages are better.
4. Lead the persuasive message with information about the benefits of J-turns, so that benefits are upfront while the individual considers how to navigate a J-turn.
5. When making decisions about reducing presentation content, testimonials should not be removed to meet time constraints.
6. Testimonials can be very effective but require credible messengers for the audience.
7. The audience can differ for the persuasive message and have different dispositions toward J-turns. For example, individuals from rural areas and older adults tend to be less accepting of J-turns, and less persuaded.

The simulation study assessed three signage levels (i.e., minimum, moderate, and full) and their impact on driver behavior and subjective reports for those drivers who had little to no exposure to J-turns. The results found no evidence of benefit from an increase in signage from moderate to full levels. Furthermore, some efficiency and workload metrics suggest that moderate signage outperformed both the minimum and full signage conditions (see Appendix B). Here are the recommendations for J-turn signage:

1. Full and minimum tested signage levels can be confusing and lead to inefficient driving behavior.
2. A moderate level of signage is appropriate.
3. Exposing drivers to J-turns through simulation or immersive videos through engagement activities may help to achieve improved performance and reduced workload as observed in the repeated exposures of the driving simulation study.

Future work should be conducted to determine how these recommendations may be useful for other types of nontraditional or novel roadway designs (e.g., roundabouts).

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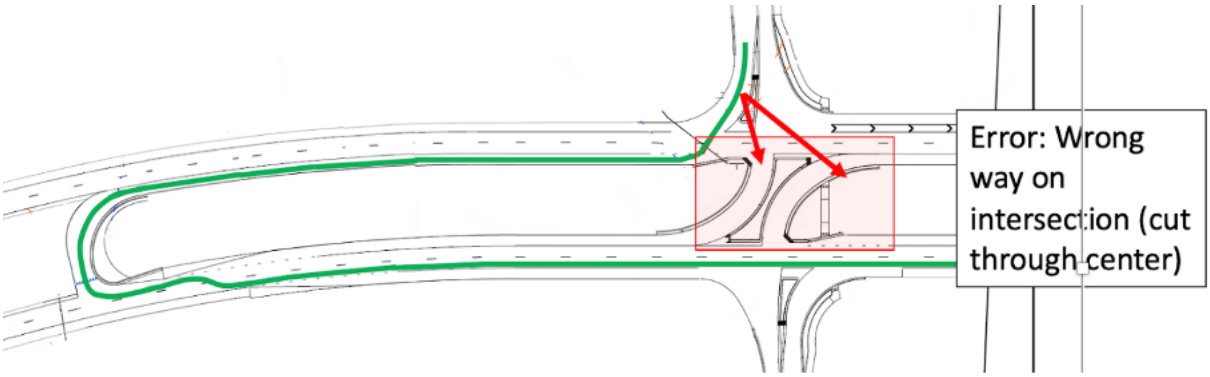
APPENDIX A

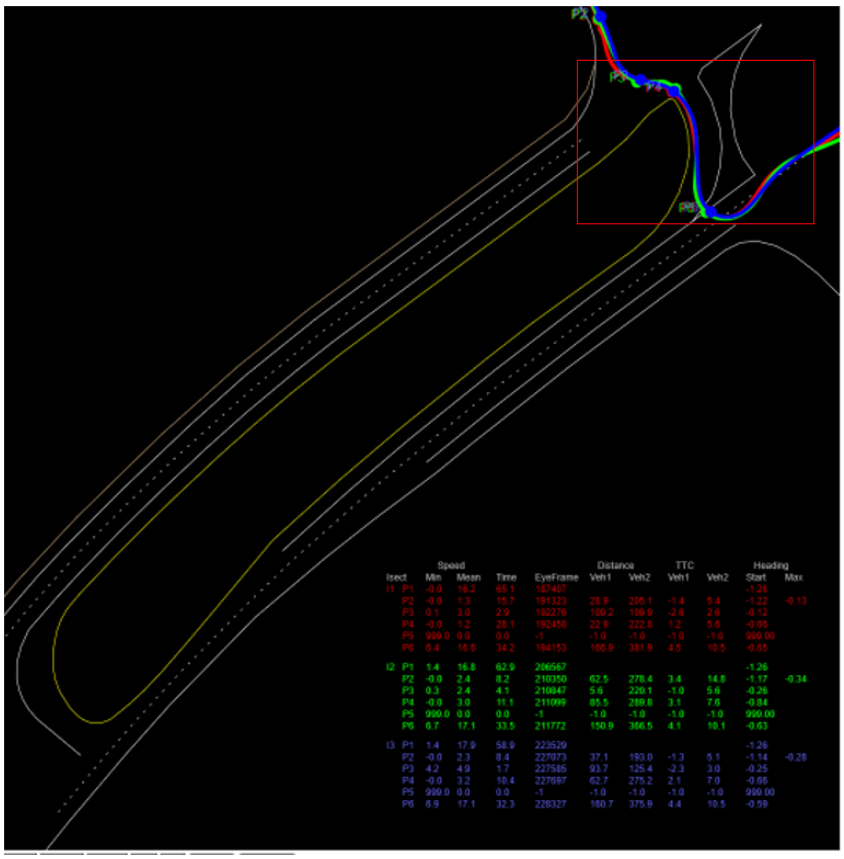
J-TURN ERRORS

Critical Error

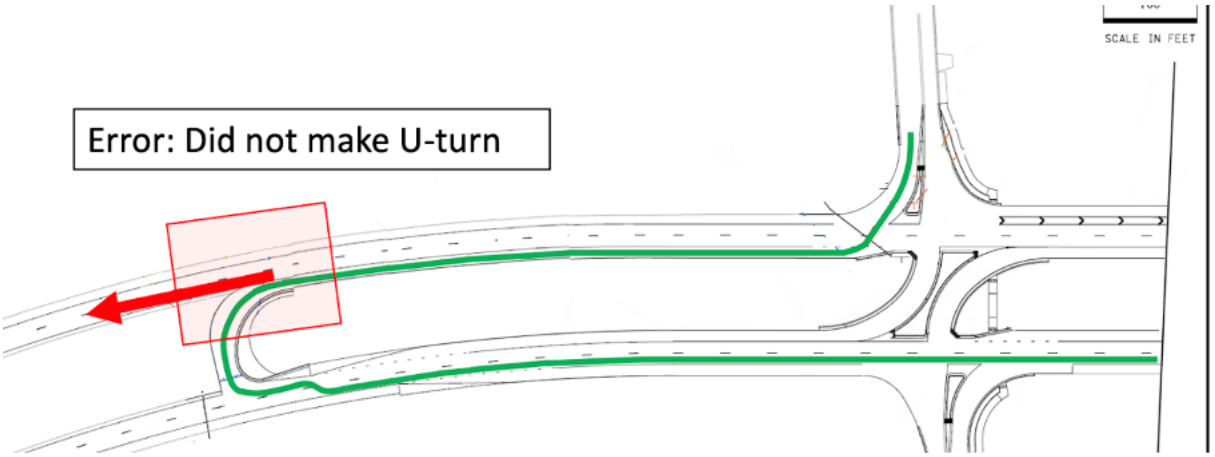
Error Type 1: Drove wrong way on intersection (i.e., drove through center)



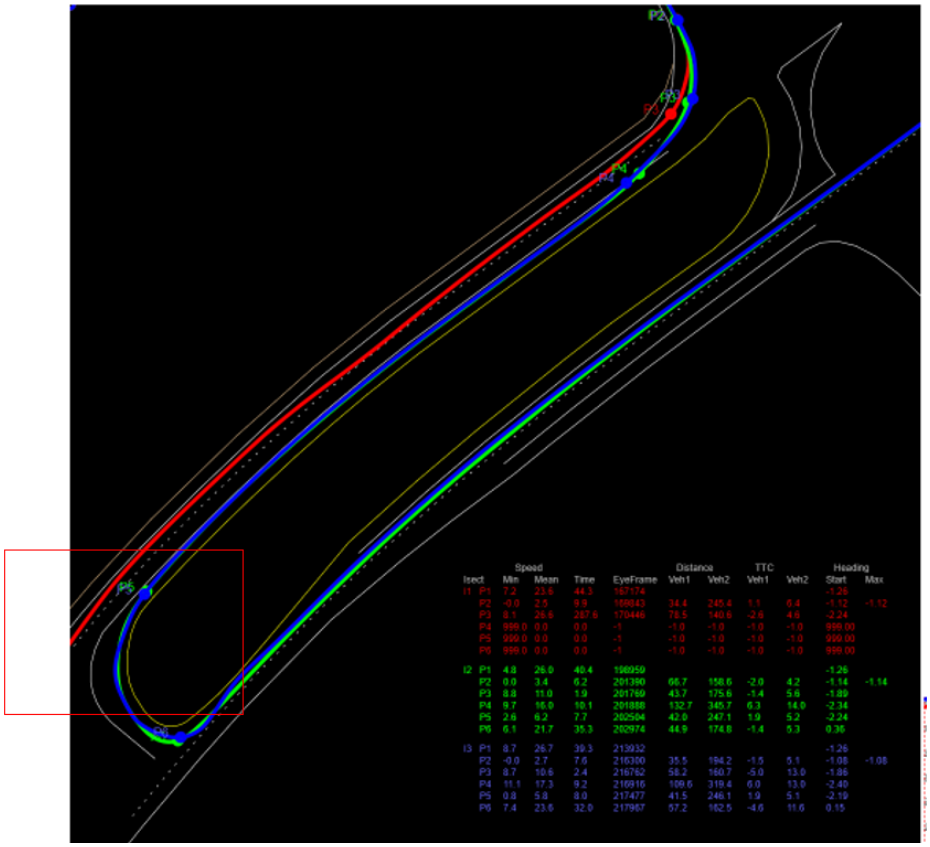
Example Path 1: Participant #6 consistently drove through the center of the intersection for all three J-turn drives.



Error Type 7: Did not make a U-Turn



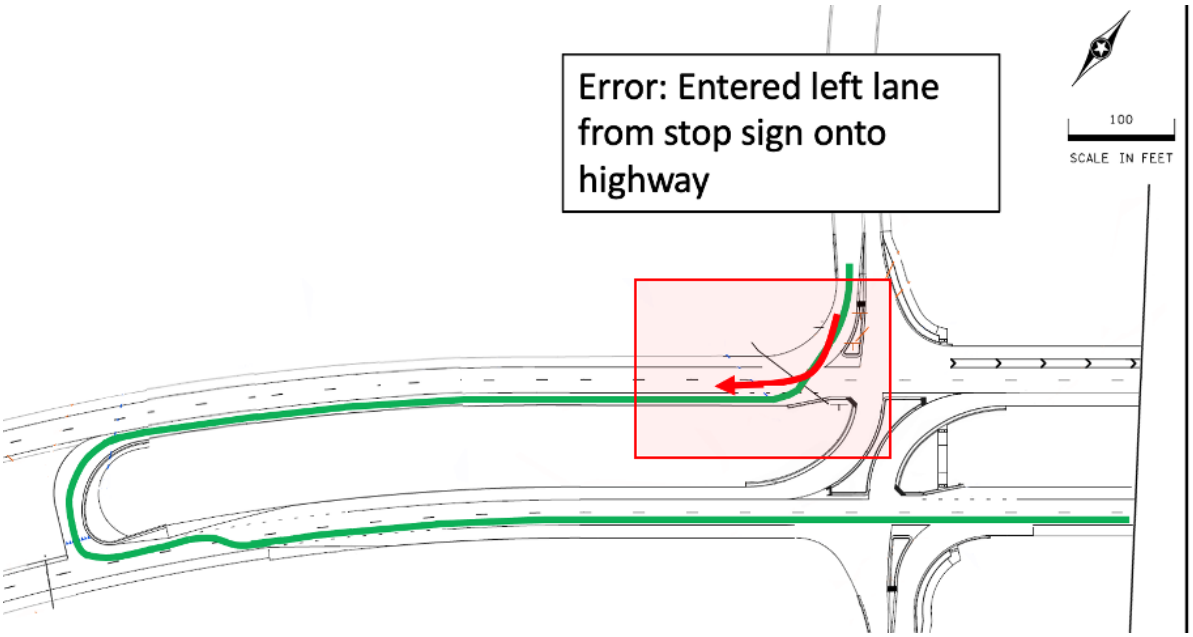
Example Path 2: Participant #47 missed the U-turn and drove through the highway during the first drive (i.e., red line), but he/she was able to successfully make the left-turns using J-turns during the subsequent drives (i.e., green and blue lines).



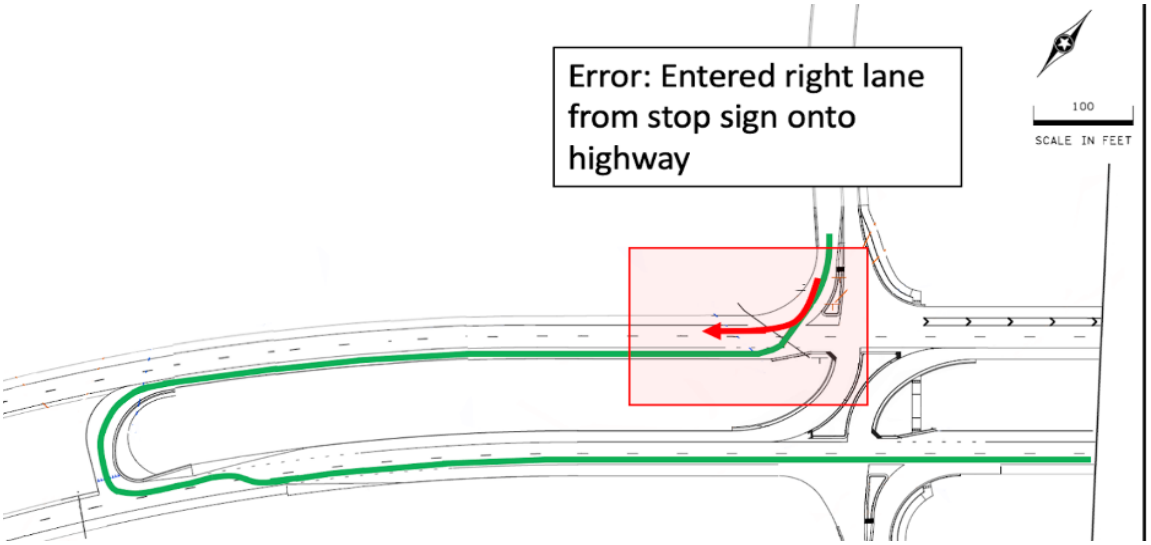
Isect		Speed Min	Speed Mean	Time	EyeFrame	Distance Veh1	Distance Veh2	TTC Veh1	TTC Veh2	Heading Start	Heading Max
I1	P1	7.2	23.8	44.3	167174					-1.26	
	P2	-0.0	2.5	9.9	188843	34.4	245.4	1.1	0.4	-1.12	-1.12
	P3	8.1	26.6	287.6	170446	78.5	140.6	-2.6	4.6	-2.24	
	P4	999.0	0.0	0.0	-1	-1.0	-1.0	-1.0	-1.0	999.00	
	P5	999.0	0.0	0.0	-1	-1.0	-1.0	-1.0	-1.0	999.00	
	P6	999.0	0.0	0.0	-1	-1.0	-1.0	-1.0	-1.0	999.00	
I2	P1	4.8	26.0	40.4	198959					-1.26	
	P2	0.0	3.4	6.2	201390	66.7	158.6	-2.0	4.2	-1.14	-1.14
	P3	8.8	11.0	1.9	201769	43.7	175.6	-1.4	5.6	-1.89	
	P4	9.7	16.0	10.1	201888	132.7	345.7	6.3	14.0	-2.34	
	P5	2.6	6.2	7.7	202504	42.0	247.1	1.9	5.2	-2.24	
	P6	6.1	21.7	35.3	202974	44.9	174.8	-1.4	5.3	0.35	
I3	P1	8.7	26.7	39.3	213932					-1.26	
	P2	-0.0	2.7	7.6	216300	35.5	164.2	-1.5	5.1	-1.08	-1.08
	P3	8.7	10.6	2.4	216762	58.2	160.7	-5.0	13.0	-1.86	
	P4	11.1	17.3	9.2	216916	109.6	319.4	6.0	13.0	-2.40	
	P5	0.8	5.8	8.0	217477	41.5	246.1	1.9	5.1	-2.19	
	P6	7.4	23.6	32.0	217957	57.2	162.5	-4.6	11.6	0.15	

<u>Non-Critical Error (Pre U-Turn Phase)</u>

Error Type 2: Entered left (far) lane from stop sign onto highway (See Example Path 3)

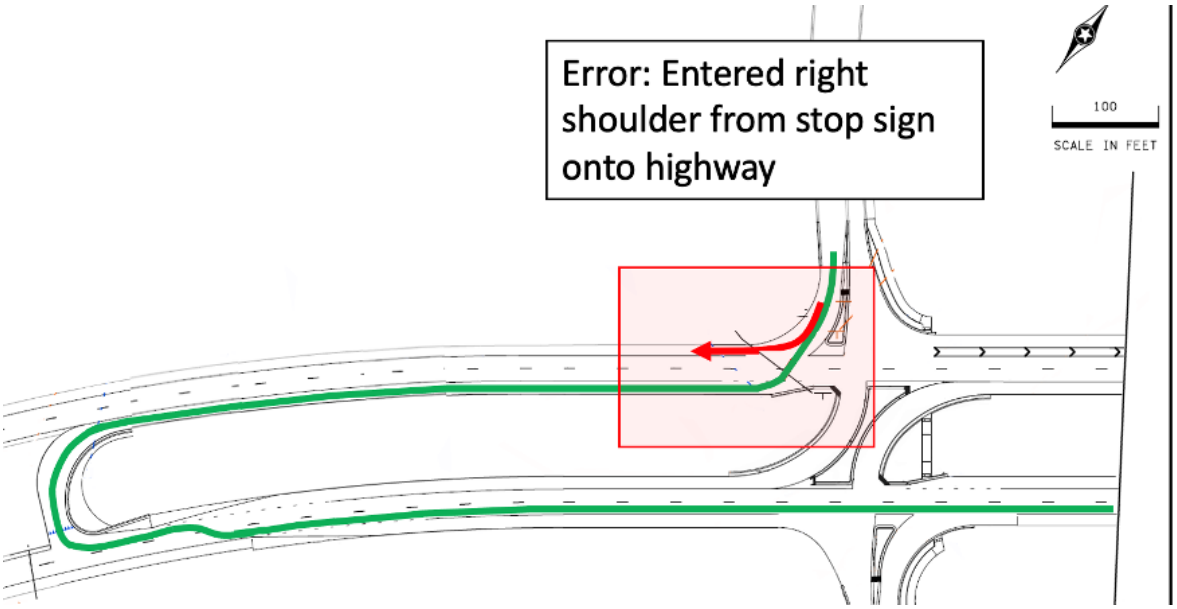


Error type 3: Entered right (near) lane from stop sign onto highway (See Example Path 3)



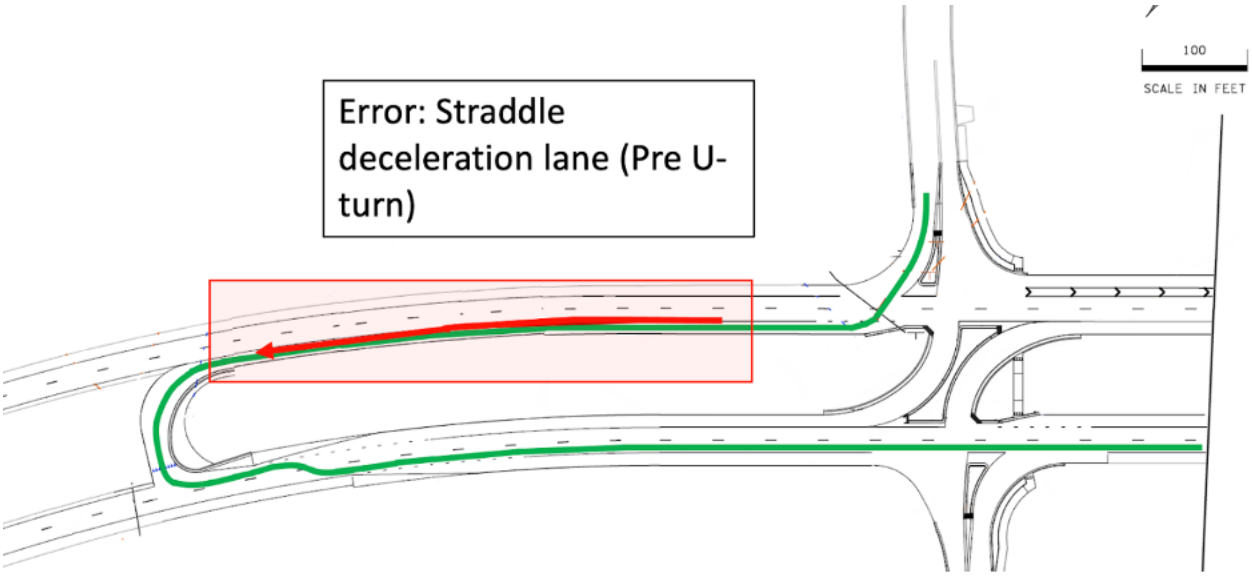
Example Path 3: Participant #70 made a Type 3 error to enter the right (near) lane from stop sign onto the highway, during the first drive (i.e., red line). Instead, the Type 2 error was observed during the subsequent drives (i.e., green and blue lines), where he/she entered the left (far) lane from stop sign onto the highway. Such a behavioral change was commonly observed among drivers in this study (also see the significant main effect of the first-time use on Type 3 and Type 2 errors, in Section 3.1.1).

Error Type 4: Entered right shoulder from stop sign onto highway or straddle right lane

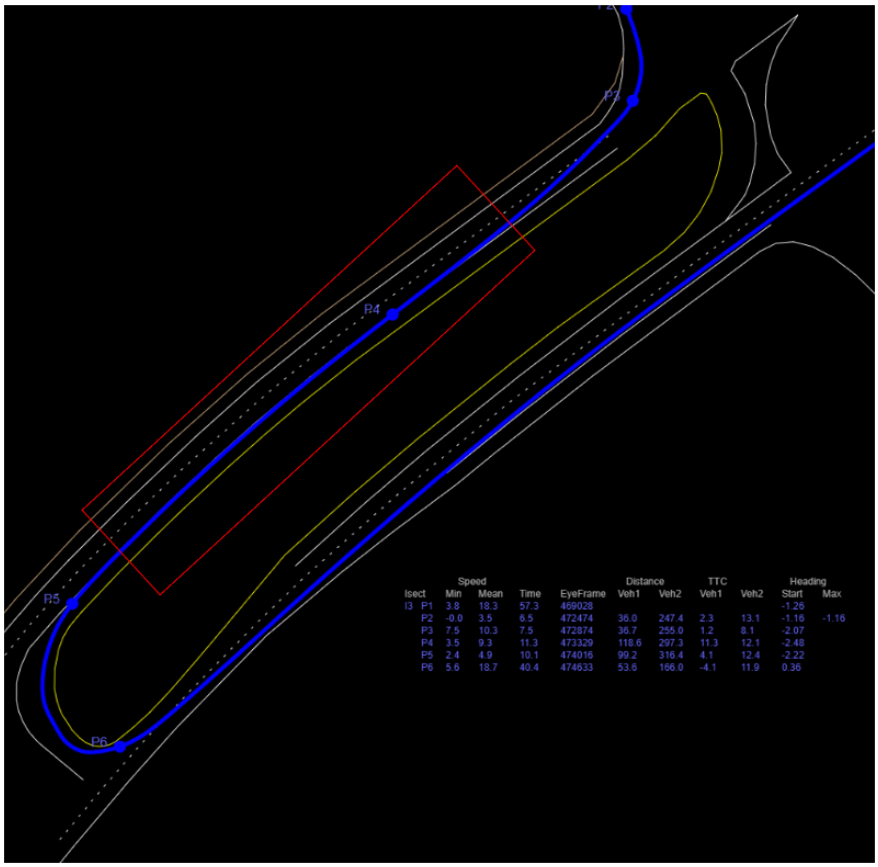


Example Path 4: Participant #62 passed the edge of the right lane and entered the right shoulder from the stop sign when turning right during the first drive (i.e., red line). Similarly, in the above Example Path 3, the Type 4 error was also identified when the center of vehicle straddled the edge of the right lane during the first drive for Participant #70.

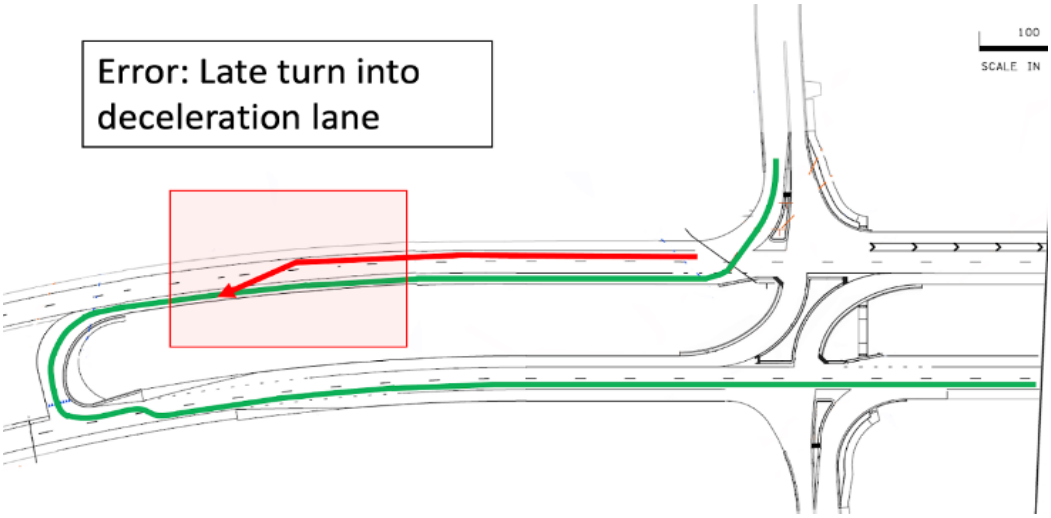
Error Type 5: Straddle deceleration lane (Pre U-turn)



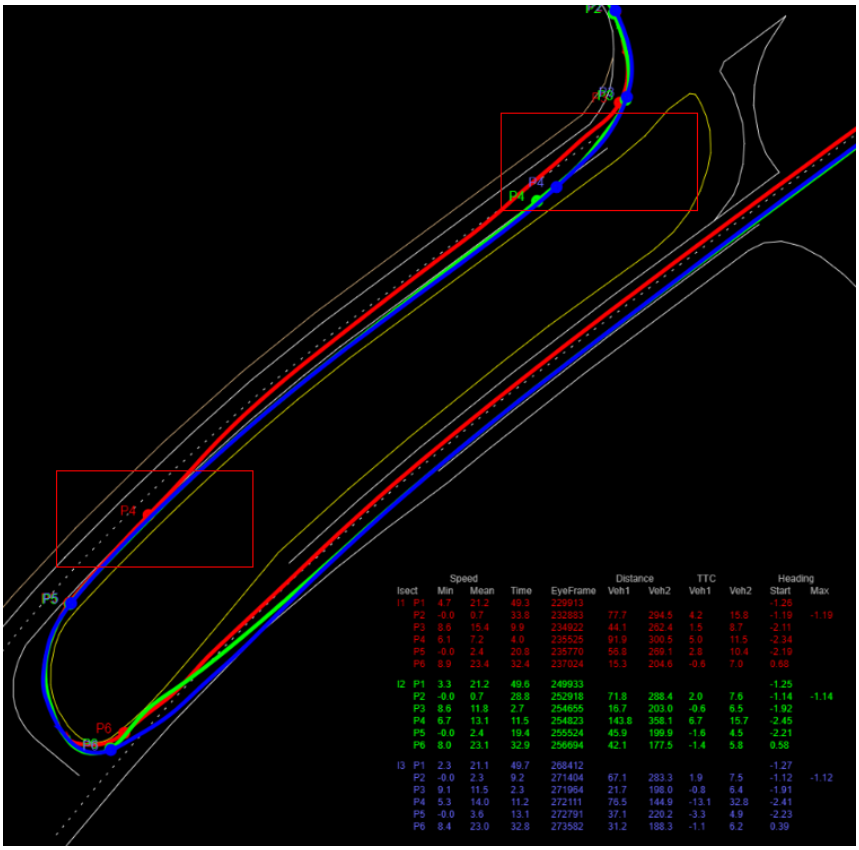
Example Path 5: Participant #43 demonstrated the Type 5 error while navigating the third J-turn intersection.



Error Type 6: Late turn into deceleration lane (< = 250 feet away from the U-turn)

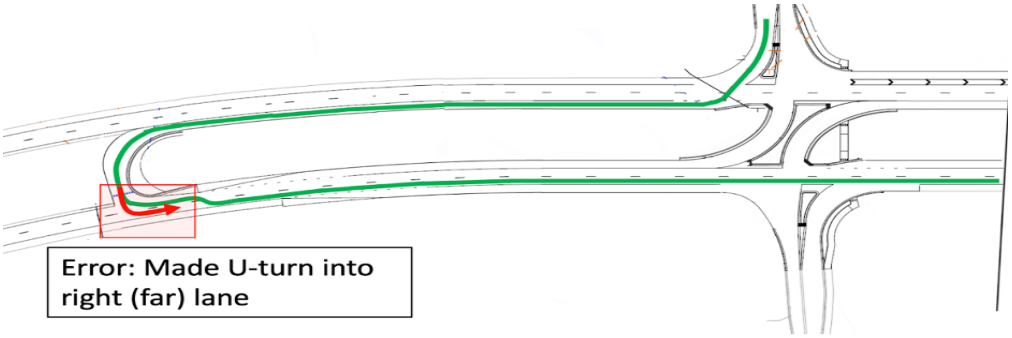


Example Path 6: During the first drive (i.e., red line), participant #36 merged into the deceleration lane (i.e., red P4 point) at a distance less than 250 feet away from the entry of the U-turn (i.e., a fixed P5 point for all J-turn intersections). However, the participant merged much earlier into the deceleration lane during the subsequent drives, where no Type 6 errors were identified. As shown in Section 3.1.1, this behavioral transition associated with the order of J-turn exposure was also common in this study.

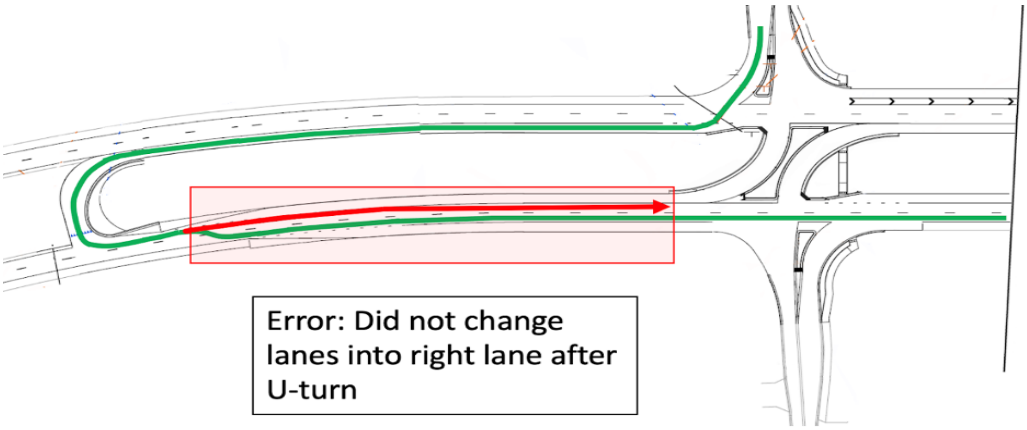


Non-critical Error (Post U-Turn Phase)

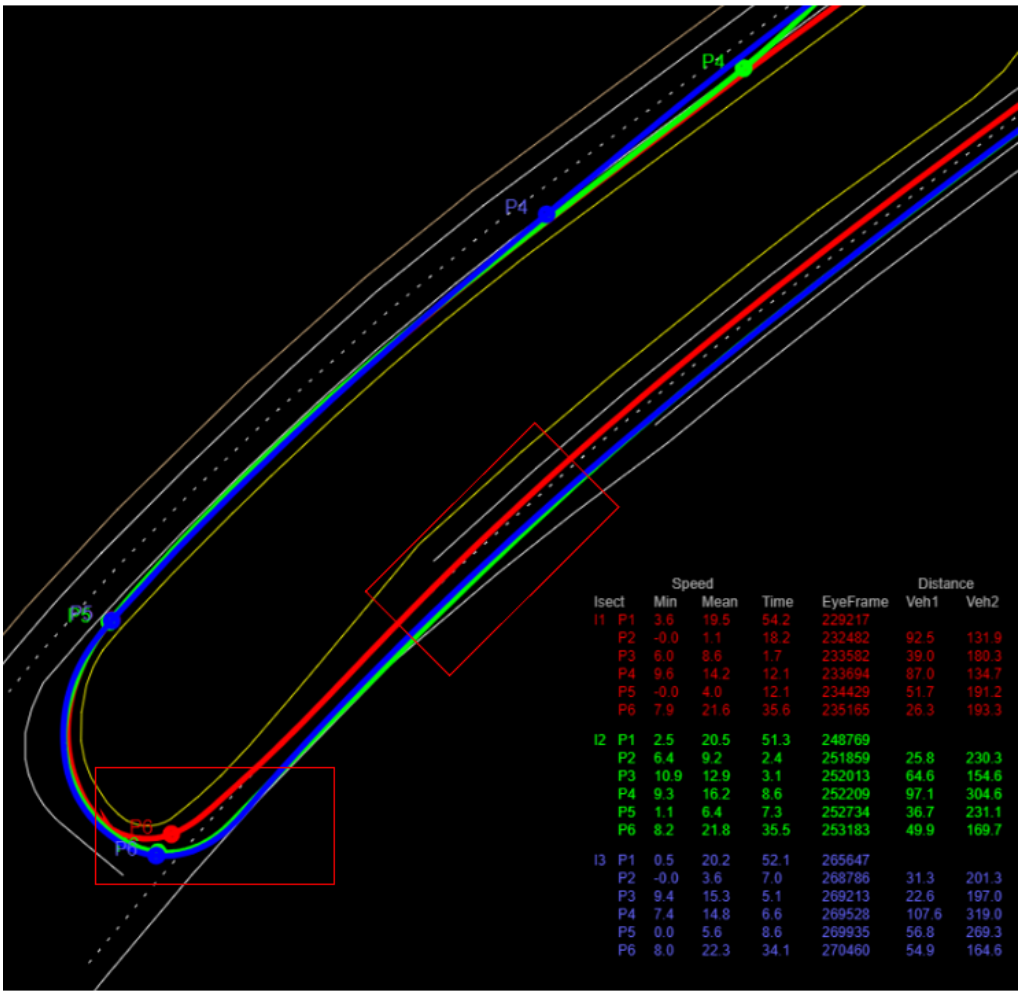
Error Type 8: Made U-turn into right (far) lane



Error Type 9: Did not change lanes into right lane after U-turn

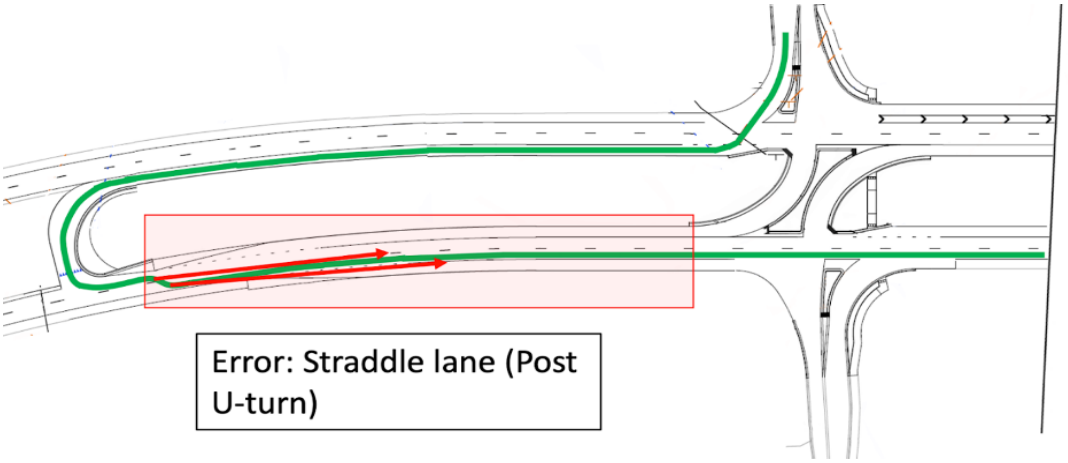


Example Path 7: During the first drive (i.e., red line), participant #23 turned into the left lane after U-turn but failed to change lanes into the right lane (Type 9 error). During the subsequent drives (i.e., green and blue lines), the participant made U-turn into the right (far) lane directly (Type 8 error).

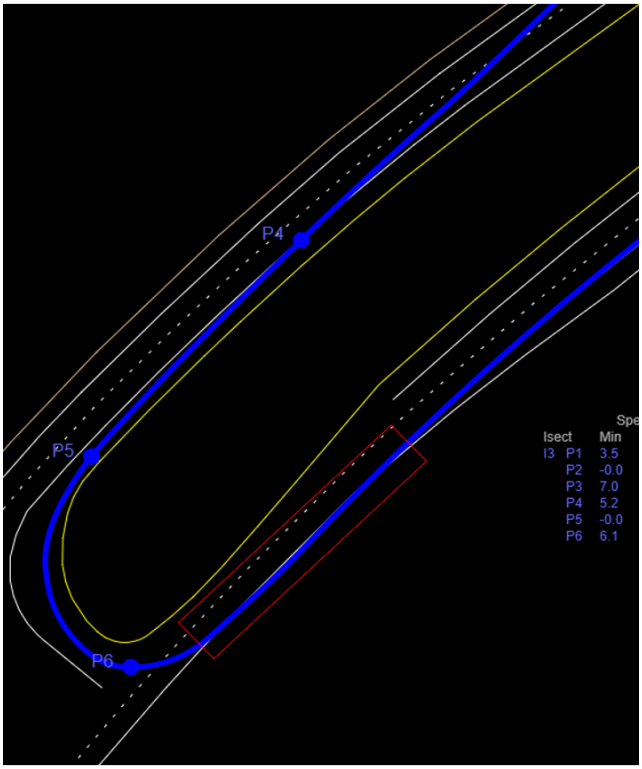


Isect		Speed Min	Speed Mean	Time	EyeFrame	Distance Veh1	Distance Veh2
I1	P1	3.6	19.5	54.2	229217		
	P2	-0.0	1.1	18.2	232482	92.5	131.9
	P3	6.0	8.6	1.7	233582	39.0	180.3
	P4	9.6	14.2	12.1	233694	87.0	134.7
	P5	-0.0	4.0	12.1	234429	51.7	191.2
	P6	7.9	21.6	35.6	235165	26.3	193.3
I2	P1	2.5	20.5	51.3	248769		
	P2	6.4	9.2	2.4	251859	25.8	230.3
	P3	10.9	12.9	3.1	252013	64.6	154.6
	P4	9.3	16.2	8.6	252209	97.1	304.6
	P5	1.1	6.4	7.3	252734	36.7	231.1
	P6	8.2	21.8	35.5	253183	49.9	169.7
I3	P1	0.5	20.2	52.1	265647		
	P2	-0.0	3.6	7.0	268786	31.3	201.3
	P3	9.4	15.3	5.1	269213	22.6	197.0
	P4	7.4	14.8	6.6	269528	107.6	319.0
	P5	0.0	5.6	8.6	269935	56.8	269.3
	P6	8.0	22.3	34.1	270460	54.9	164.6

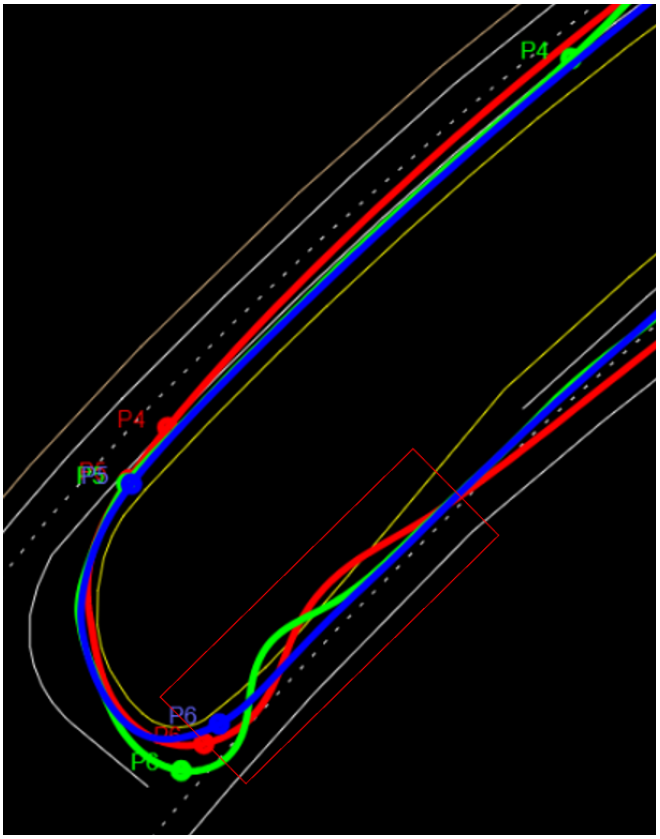
Error Type 10: Straddle lane or swerving (Post U-Turn)



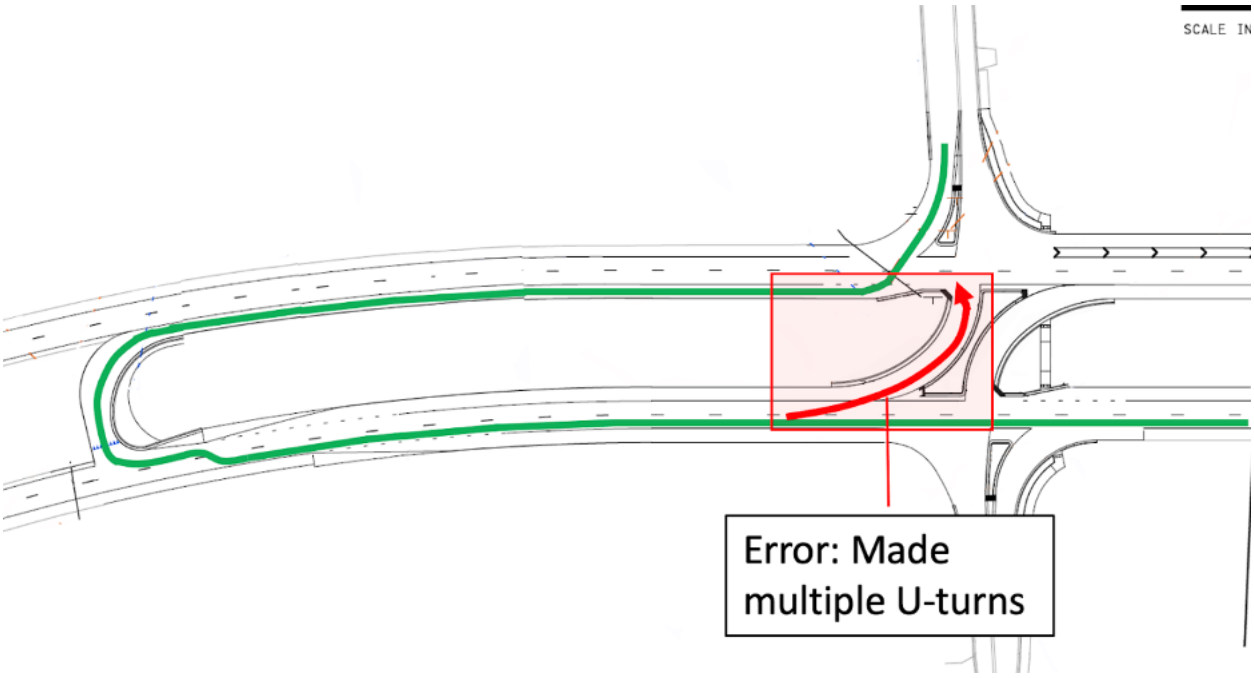
Example Path 8: During the third J-turn drive (i.e., blue line), participant #57 turned into the shoulder and straddled the edge of the right lane after the U-turn.



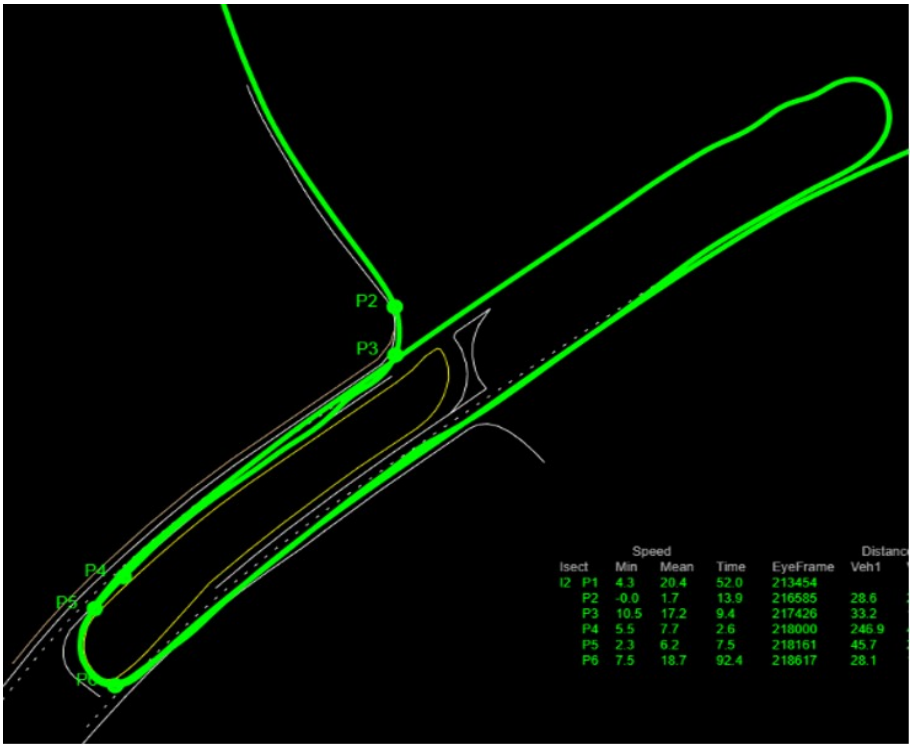
Another example of Error Type 10: In the study, there were also a few drives where the participants appeared to lose control of their vehicle immediately after U-turn. The below figure provided the driving paths for participant #71, where a swerving behavioral was observed during the first and second J-turn drives (i.e., red and green lines, respectively).

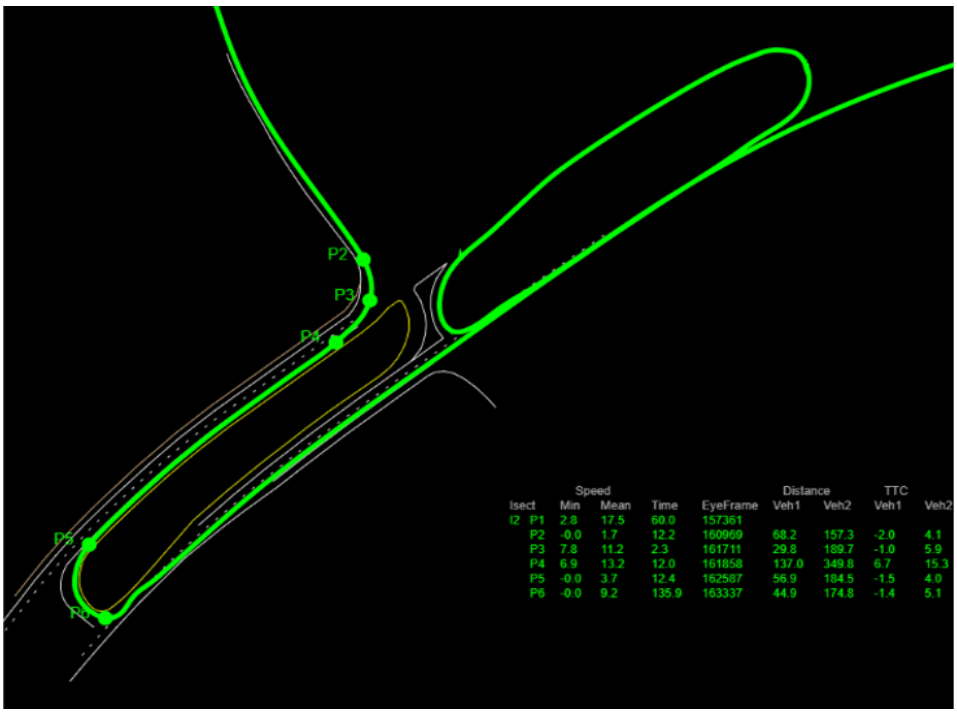


Error Type 11: Made multiple U-turns



Example Path 9: Below two figures provided examples of how participants could have made a Type 11 error (i.e., the second drive for Participant #32 and Participant #65, respectively).

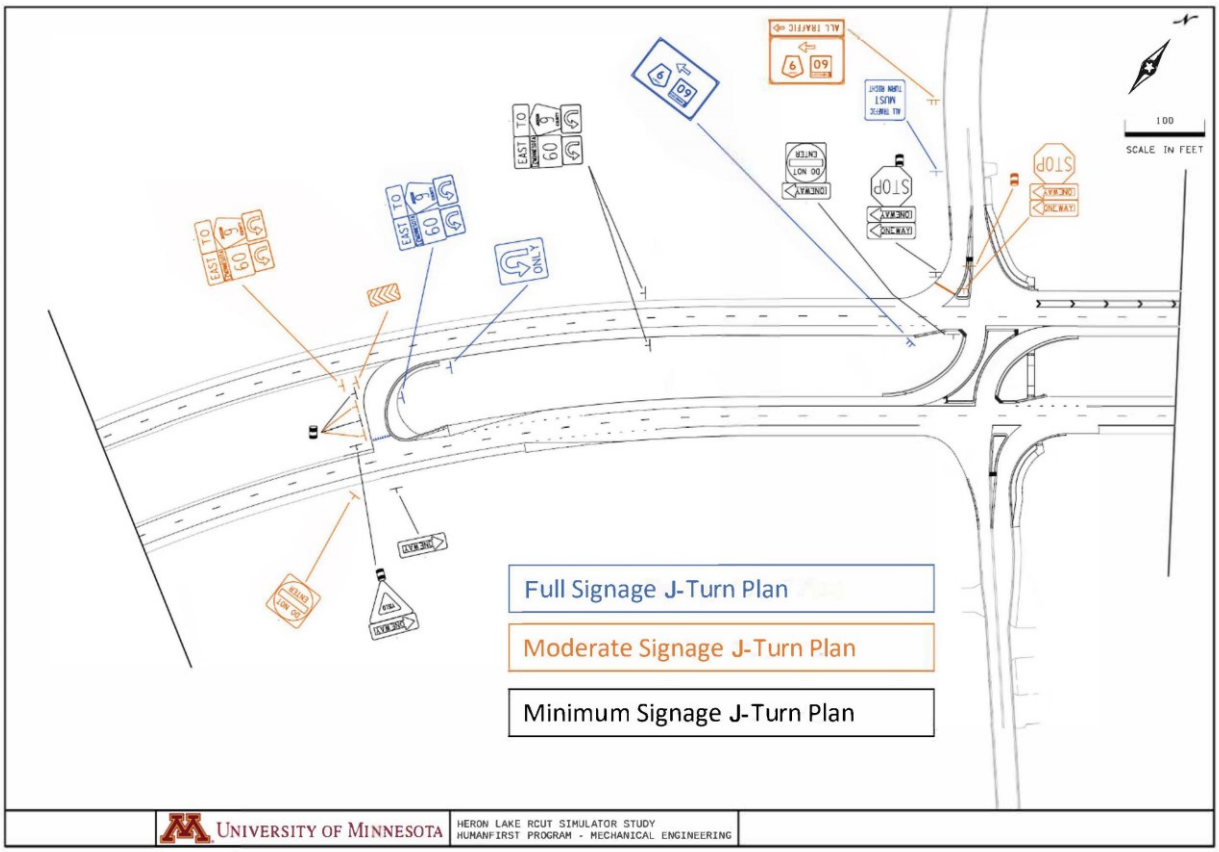




Late turn was defined when the distance of P4 segment was less or equal to 250 feet away from the entry of the U-turn (Ranging from 0 to 569.8 feet, Median = 117.2 feet). Below figure shows one participant who merged into the deceleration lane at a distance of 217.4 feet away from the entry of the U-turn (i.e., cut-off point of P4).

APPENDIX B

J-TURN SIGNAGE LEVELS


100
SCALE IN FEET
Full Signage J-Turn Plan
Moderate Signage J-Turn Plan
Minimum Signage J-Turn Plan
UNIVERSITY OF MINNESOTA
HERON LAKE RCUT SIMULATOR STUDY
HUMANFIRST PROGRAM - MECHANICAL ENGINEERING

APPENDIX C

STATE FAIR/TESTIMONIAL/LARGE SAMPLE MATERIALS

BENEFITS OF AN RCUT INTERSECTION

- Reduces the opportunity for a severe multi-vehicle crash by more than 80%, because of fewer vehicle-to-vehicle conflict points than a conventional intersection.
- Takes approximately one year to design and build versus 3-5 years for an interchange
- A fraction of the cost of building an interchange
- Reduces back-ups on minor road because vehicles do not have to wait for gaps in traffic in both directions
- Provides local access to a main highway while delivering safer, more efficient travel
- Maintains access to local businesses and commercial areas because the U-turn accommodate all movements

80% LESS OPPORTUNITY FOR SEVERE CRASH

10X LESS EXPENSIVE THAN INTERCHANGE

FREQUENTLY ASKED QUESTIONS

Q: Why not just install a traffic signal?
A: Traffic signals have been shown to increase the number of crashes on high-speed rural intersections. Compared to an RCUT, a signalized intersection has 33% more accidents.

Q: How will large trucks and farm equipment use an RCUT?
A: With an RCUT, trucks are exposed less time to oncoming traffic than at a conventional four-lane divided highway intersection. In some locations, MnDOT installs a "truck apron" to help larger vehicles make the wide turn at the median U-turn opening.

Q: Will the RCUT intersection take me more time to get to where I need to go?
A: In most situations, motorists will actually save time navigating the highway with an RCUT instead of a traditional intersection. Why? Because motorists only have to wait for one direction of traffic to clear. The total travel distance is typically one-quarter of a mile.

Q. Are there other names that refer to this type of intersection?
A. Yes, an RCUT is also referred to as a Reduced Conflict Intersection (RCI), U-Turn, J-Turn, or Michigan Left Turn intersection.

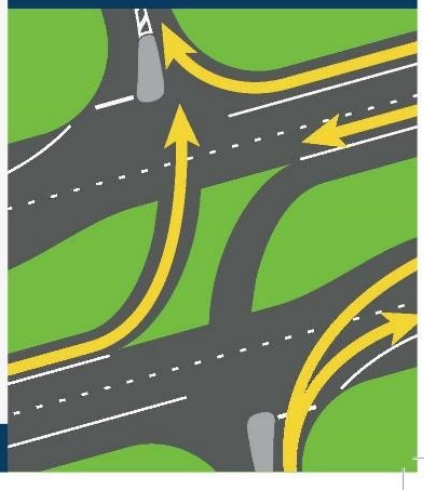
DEPARTMENT OF TRANSPORTATION

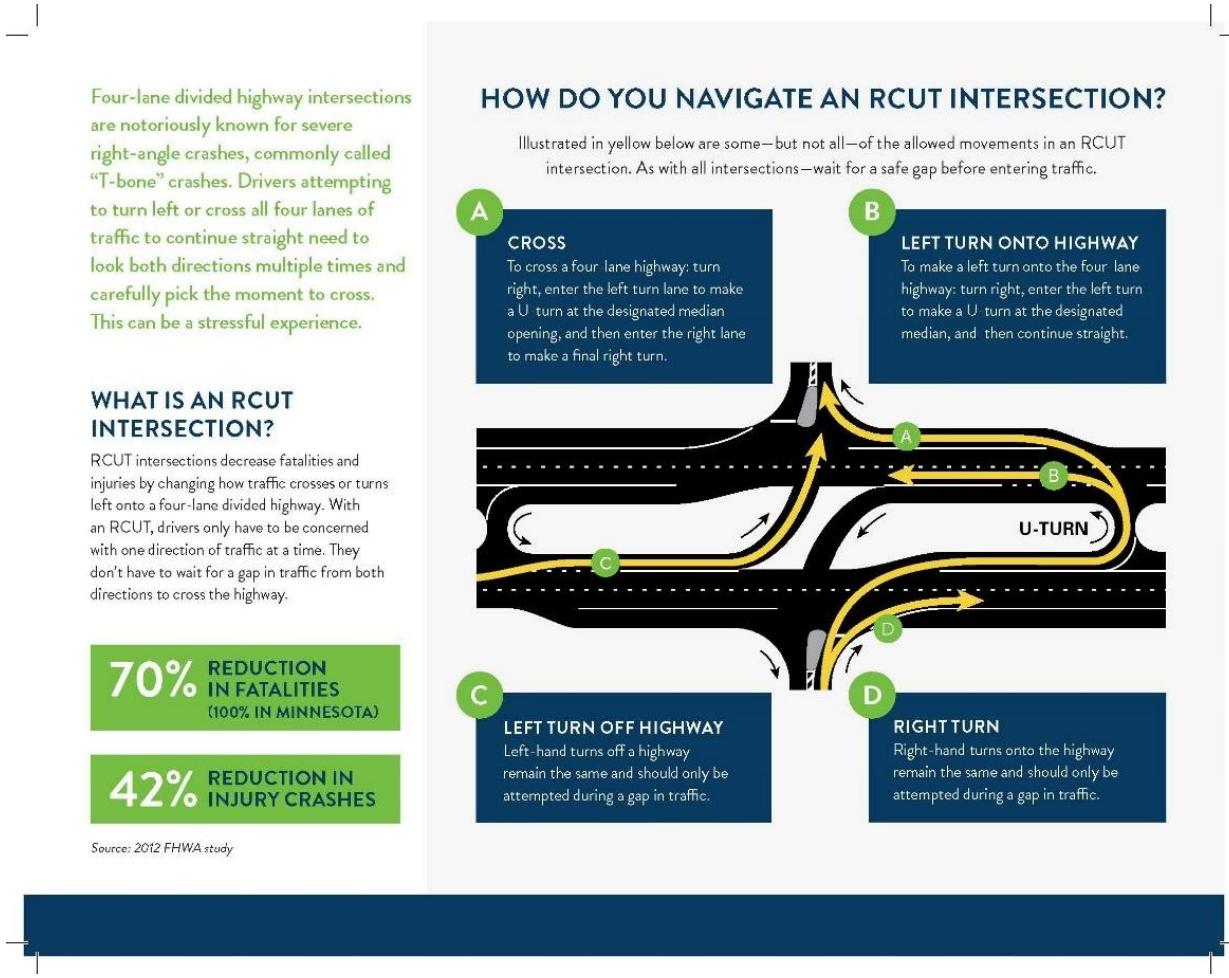
MnDOT is planning and studying future locations for RCUTs across Minnesota. Visit our website to find out more. www.mndot.org

DEPARTMENT OF TRANSPORTATION

Restricted Crossing U-Turn (RCUT) Intersections

INCREASING SAFETY, DECREASING CRASHES





Driving History Questionnaire

This questionnaire asks you to indicate some details about your driving history and related information. Please tick one box for each question.

1. Your age: _____ years
2. Your gender:
   - ❑ Male
   - ❑ Female
   - ❑ Other

3. What is your highest educational level completed?

   - ❑ High School / Vocational School
   - ❑ Associate Degree
   - ❑ Bachelor of Arts / Bachelor of Science
   - ❑ Masters
   - ❑ PhD

4. Are you currently taking any college level classes?

- ❑ Yes
- ❑ No

5. Please state your occupation: _____

6. Please state the year when you obtained your full driving license: _____

7. About how often do you drive nowadays?

- ❑ Never
- ❑ Hardly
- ❑ Sometimes
- ❑ Most Every Day
- ❑ Every Day

8. Estimate roughly how many miles you personally have driven in the past year:

- ❑ Less than 5000 miles
- ❑ 5000-10,000 miles
- ❑ 10,000-15,000 miles
- ❑ 15,000-20,000 miles
- ❑ Over 20,000 miles

9. About how often do you drive to and from your place of work or school?

- ❑ Never
- ❑ Hardly Ever
- ❑ Sometimes
- ❑ Most Every Day
- ❑ Every Day

10. Do you drive frequently on…

Highways?

- ❑ Yes
- ❑ No

Main Roads other than Highways?

- ❑ Yes
- ❑ No

Urban Roads?

- ❑ Yes
- ❑ No

Country Roads?

- ❑ Yes
- ❑ No

11. During the last three years, how many minor traffic crashes have you been involved in where you were at fault? A minor crash is one in which no-one required medical treatment, AND costs of damage to vehicles and property were less than $1500.

Number of minor accidents ____ (if none, write 0)

12. During the last three years, how many major traffic crashes have you been involved in where you were at fault? A major crash is one in which EITHER someone required medical treatment, OR costs of damage to vehicles and property were greater than $1500, or both. Number of major accidents ____ (if none, write 0)

13. Have you had a crash or near-miss experience at an intersection?

- ❑ No
- ❑ Yes, in the last 5 years
- ❑ Yes, in the last 10 years
- ❑ Yes, greater than 10 years ago

14. Has someone close to you been involved in a fatal or serious injury crash at an intersection?

- ❑ No
- ❑ Yes, in the last 5 years
- ❑ Yes, in the last 10 years
- ❑ Yes, greater than 10 years ago

15. During the last three years, have you ever been convicted for:

Speeding

- ❑ Yes
- ❑ No

Distracted, careless or dangerous driving

- ❑ Yes
- ❑ No

Driving under the influence of alcohol/drugs

- ❑ Yes
- ❑ No

16. What type of vehicle do you drive most often?

- ❑ Motorcycle
- ❑ Passenger

- ❑ Car Pick-Up
- ❑ Truck
- ❑ Sport utility vehicle
- ❑ Van or Minivan
- ❑ Other, briefly describe: _____

Driver History Questionnaire

Have you had a crash or near-miss experience at an intersection?

- No
- Yes, in the last 5 years
- Yes, in the last 10 years
- Yes, greater than 10 years ago

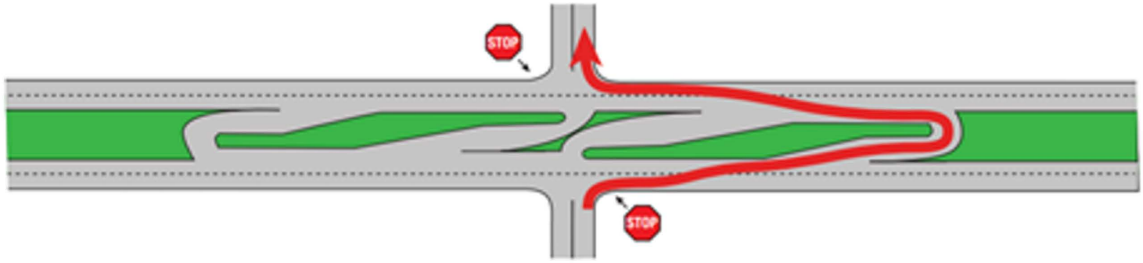
Has someone close to you had a crash or near-miss experience at an intersection?

- No
- Yes, in the last 5 years
- Yes, in the last 10 years
- Yes, greater than 10 years ago
- Unsure

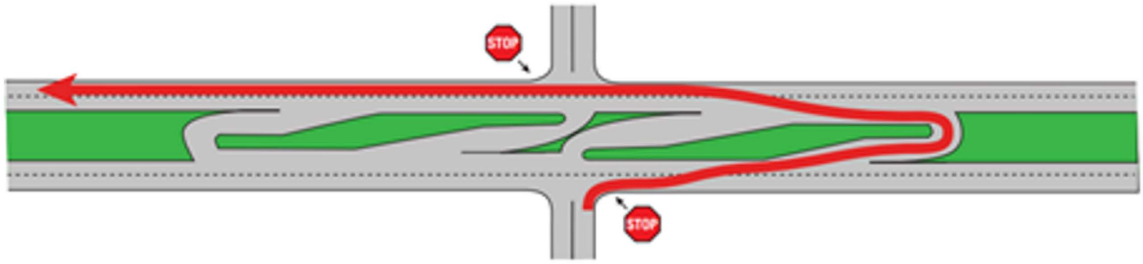
Pre RCUT

Restricted Crossing U-Turns (RCUTs) are sometimes referred to as J-turns, RCIs, or superstreet intersections. A traditional intersection on a four-lane divided highway allows drivers at the stop sign to pass freely through the intersection to drive straight through, turn left, or right. In a Restricted Crossing U-Turn (RCUT), drivers always make a right turn, followed by a U-turn when they want to go straight or turn left.

Crossing a rural divided highway using a Restricted Crossing U-Turn



Left hand turn onto a divided highway using a Restricted Crossing U-Turn



How familiar are you with Restricted Crossing U-Turn Intersections (J-turns)?

- I have never heard of J-turns
- I have heard of J-turns but am not very familiar
- I have heard of J-turns and am somewhat familiar
- I have heard of J-turns and am very familiar

How much experience do you have crossing Restricted Crossing U-Turn Intersections (J-turns)?

- I have never crossed a J-turn
- I have crossed a J-turn once or twice
- I occasionally cross J-turns
- I frequently cross J-turns

J-Turn Attitudes Questionnaire

1. Do you think J-turns are a good idea?
    - Definitely not
    - Probably not
    - Possibly Not
    - Neutral
    - Possibly
    - Probably
    - Definitely
2. Are you willing to drive on a J-turn?
    - Definitely Not
    - Probably Not
    - Possibly Not
    - Neutral
    - Possibly
    - Probably
    - Definitely
3. Would you be supportive of a J-turn to be placed in your community?
    - Definitely Not
    - Probably Not
    - Possibly Not
    - Neutral
    - Possibly
    - Probably
    - Definitely

APPENDIX D

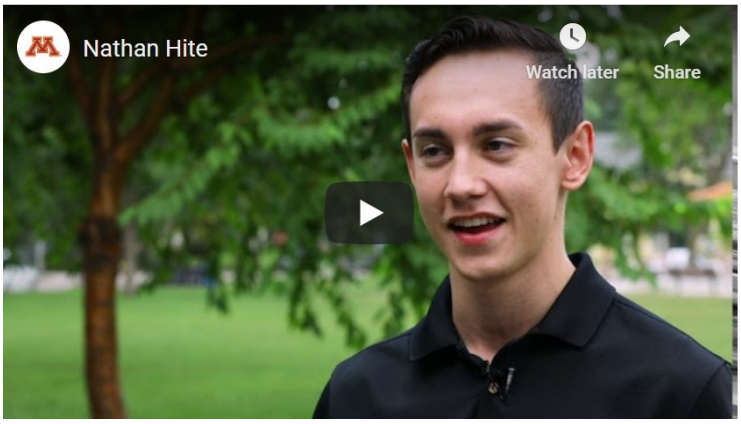
TESTIMONIALS VIDEOS

Video A: Grocery Operations Manager

Video B: City Administrator

Video C: Grocery Store Owner

Video D: Young Driver



Video E: Vehicle Sales General Manager

Video F: State Trooper

Video G: Older/Parent Driver

Video H: Restaurant General Manager

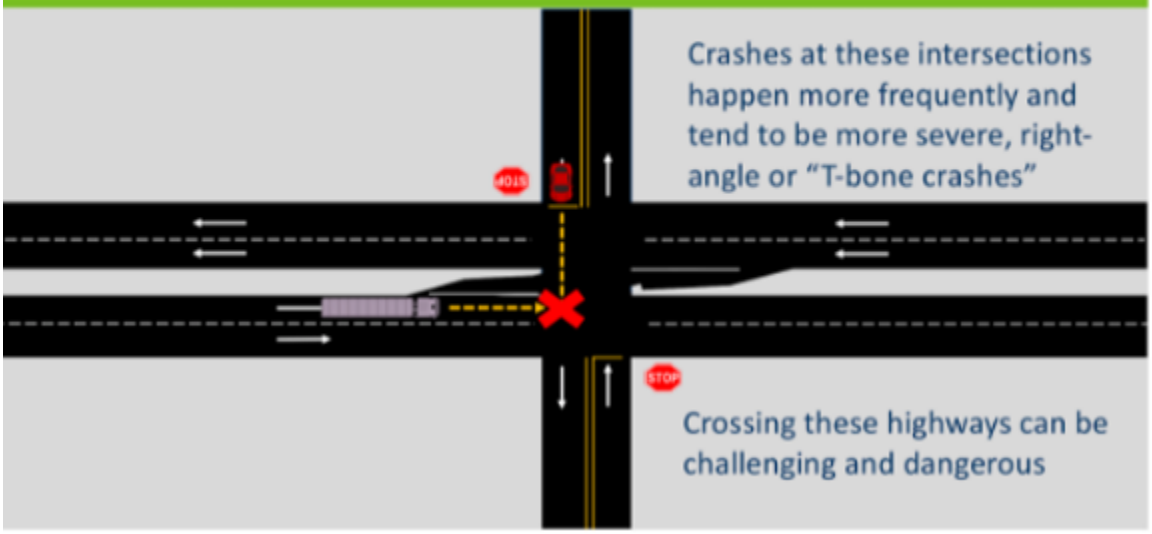
APPENDIX E

STAKEHOLDER/COMMUNITY ENGAGEMENT

Restricted Crossing U-Turn (RCUT)

DEPARTMENT OF TRANSPORTATION

Traditional Four-Lane Divided Highway Intersections



Crashes at these intersections happen more frequently and tend to be more severe, right-angle or "T-bone crashes"

Crossing these highways can be challenging and dangerous

One Solution:
The Restricted Crossing U-Turn or RCUT

- MnDOT is building a new type of intersection to reduce these crashes called:
- **Restricted Crossing U-Turn**
  - *Sometimes called*
    - Restricted Crossing Intersection (RCI)
    - Reduced Conflict Intersection
    - J-Turn

The RCUT Alternative

- The RCUT is an alternative to traditional intersections along high speed multi-lane highways
  - They improve **safety** and **efficiency** for drivers
- They are installed at locations with a history or high risk of severe or life altering crashes

Focusing on Traffic One Direction at a Time

Crossing or Turning Left Through the RCUT

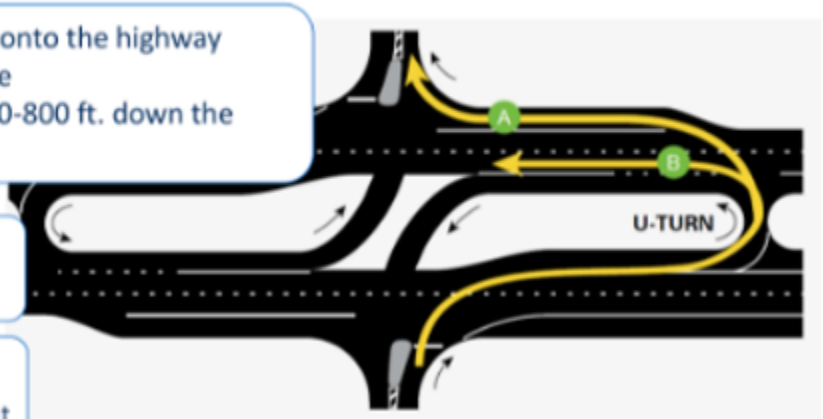
1. Make a right turn onto the highway
2. Enter the turn lane
3. Make a U-Turn 600-800 ft. down the road

A

Crossing Straight
4. Make a right

B

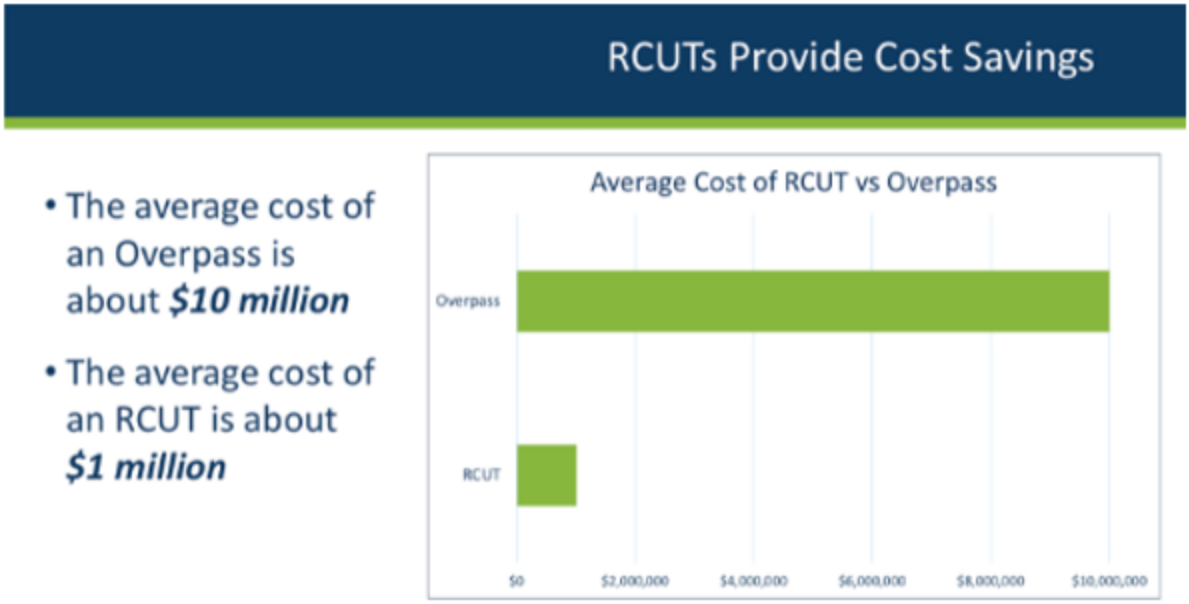
Turning Left
4. Continue straight




James Erwin
Watch later
Share
YouTube

RCUTs Reduce Serious Injury and Fatal Crashes

- Restricted Crossing U-Turns (RCUTs) save lives.
  - 80% less opportunity for severe crashes
  - 33% fewer crashes than a stoplight
  - 70% fewer fatalities
  - 42% fewer injury crashes



Debrief Questionnaire Stakeholder Study

1. Overall, what are your thoughts on the J-turn that you haven't been able to otherwise convey in the survey?
2. What did you think about the materials we presented you with today?
3. How well do you think these materials and message would resonate with your constituents?
4. Do you think this type of messaging could help communicate other types of road designs?
5. What are some missteps or poor communication strategies that you have seen, if any, in how the state or county approaches communities about roadway change?
6. What else would you like to discuss about this topic?