AN ABSTACT OF THE THESIS OF

Patrick O. Burns for the degree of Honors Baccalaureate of Science in Civil Engineering presented on January 31, 2014. Title: Visual Search Patterns and Behavior of Left Turning Bicyclists at Roadway Intersections: A Field Study.

Abstract approved: ____
David S. Hurwitz

This research effort considers bicyclist's left-turn behavior at roadway intersections with varying levels of traffic control; specifically, seeking to address the question where do bicyclists look to acquire information. A demographic comparison was made to determine if factors such as gender or experience influence the nature of how a bicyclist navigates left-turns. Eighteen research participants were outfitted with a mobile-eye tracking device that recorded their visual search patterns at each intersection. After acquiring the data, characteristics such as total number of glances, time from intersection of first glance backwards, and others were extracted and compared with the demographics. It was determined that different intersection designs (signalized vs. unsignalized) influenced the visual search patterns of bicyclists. Bicyclists also look left more often than right when they are turning left at an unsignlaized intersection that does not have a stop sign. While approaching an intersection with on-street parking on both sides, bicyclists significantly reduced their total number of glances back due to the restricted width of the road. Bicyclists exhibited more caution at signalized intersections when compared with unsignalized intersections. There were no statistically significant differences amongst experience and gender.

Key Words: Bicyclist, Left-turn, Intersections, Visual search, Glance, Behavior

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Visual Search Patterns and Behavior of Left Turning

Bicyclists at Roadway Intersections: A Field Study

by

Patrick O. Burns

A PROJECT

submitted to

Oregon State University

University Honors College

in partial fulfillment of
the requirements for the
degree of

Honors Baccalaureate of Science in Civil Engineering (Honors Scholar)

Presented January 31, 2014
Commencement June 2014

Honors Baccalaureate of Science in Civil Engineering project of Patrick O. Burns presented on January 31, 2014.

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DEDICATION

I would like to thank my mentor, Dr. David Hurwitz for his guidance and assistance throughout this project. I would also like to thank Patrick Marnell and Joshua Swake for their help with the mobile XG eye-tracking device. Thanks are also due to all the participants who took place in this research.

EXECUTIVE SUMMARY

Bicyclists turning left at an intersection face a more difficult task than left turning vehicular traffic. This is because many intersection features favor vehicles. Bicyclists, already at greater risk when compared with vehicles, must assume the role of a vehicle to properly perform a left turning maneuver. To safely perform a left turning maneuver, bicyclists must allocate visual attention to the surrounding vehicles, pedestrians, and a variety of intersection design elements. The focus of this research project is to evaluate the visual search task of bicyclists performing a left turn maneuver at intersections with varying levels of control.

To test the visual search patterns of left turning bicyclists, 18 subjects were equipped with a mobile XG eye-tracking device. Along with the test, a demographic questionnaire was collected from each participant to determine if any correlations exist with regards to experience or gender. The course used for this research encompassed the intersections of 14th and Jefferson, 11th and Jefferson, 11th and Monroe, and 14th and Monroe in Corvallis, Oregon. The intersections of 14th and Jefferson and 14th and Monroe were signalized intersections whereas the intersections of 11th and Jefferson and 11th and Monroe were unsignalized four-way intersections with two-way stop control.

The following research questions were considered for each subject at each intersection: How many times does the subject look left and right, how many total times does the subject glance back, how much time before approaching the intersection does the subject have when they glance back and merge lanes, and how much time elapses between the last glance back and lane merge? Each question was then checked with three hypotheses listed below.

1. *H_O: There is no difference in the visual search patterns and behavior of bicyclists at intersections with different levels of control.*
2. *H_O: There is no difference in the visual search task and behavior of experienced and non-experienced bicyclists at intersections.*
3. *H_O: There is no difference in the visual search task and behavior of males and females at intersections.*

The following results were obtained:

- Subjects looked left an average of 0.5 times more than they looked right in all four intersections.
- Statistically significant differences (p-value < 0.05) supported the observation that bicyclists look left more than right at the intersections of 14th and Jefferson (signalized), 11th and Jefferson (unsignalized), and 14th and Monroe (signalized).
- Bicyclists glance back significantly less when on a roadway with no bike lanes and parking on both sides (11th and Monroe).
- Bicyclists glanced backwards further upstream of the signalized intersection of 14th and Jefferson than the unsignalized intersection of 11th and Jefferson.
- Bicyclists merged further upstream of signalized intersections (14th and Jefferson and 14th and Monroe) than the unsignalized intersection (11th and Jefferson).
- Females gave themselves significantly more time to glance and merge while at signalized intersections when compared with males.

Other comparisons regarding experience and gender revealed little to no statistically significant differences, however, graphically there seem to be differences and it is recommended to test this research using a larger data set.

1 INTRODUCTION

Over the years adaptations have been introduced to the traveled way for the purpose of improving the safety of bicyclists traveling on streets such as increasing the frequency and width of bike lanes. One difficulty faced by bicyclists is the navigation of a left turn at an intersection. During this situation, a bicyclist must merge with traffic and act as another vehicle. At signalized intersections the bicyclist must transfer from the bike lane to the left turn lane by crossing the opposing direction of traffic. Since bicyclists must obey the same laws as vehicles and behave in the same manner, the question of whether or not these individuals are receiving the appropriate information from intersections in order to navigate through safely is particularly consequential. The same problem occurs on 4-way intersections in which the bicyclist must maneuver from the bike lane to the vehicle lane. These maneuvers require concentration and timing in order for the maneuver to take place safely. If bicyclists are navigating these difficult maneuvers without focusing on the cars and signs around them a safety concern exists because bicyclists in particular are vulnerable users. In order to maneuver from the bike lane to the left turn there must be evidence that bicyclists are receiving the proper information in order to do so safely.

1.1 Research Objectives

Similar to motor vehicles performing a left turn movement through an intersection, bicyclists must cross the path of oncoming vehicles. In addition to this movement, bicyclists must also cross the vehicle lane immediately adjacent to them in order to assume position of a motor vehicle. This extra movement increases the number of conflict points with motor vehicles. Although other aspects regarding the safety of bicyclists on roadways have been studied, there is limited information regarding the visual search patterns of a bicyclist as they approach and turn left through an intersection.

This research was conducted using mobile eye-tracking equipment to study the visual search patterns of bicyclists as they performed left turn maneuvers at a variety of intersections. The primary goal of the research was to gather and collect statistical data in order to better understand the visual search tasks and behavior of bicyclists turning left through various intersections. This information would ultimately be useful for traffic engineers to design safer intersections for bicyclists as well as other users. In total, 18 subjects completed the course, which encompassed four intersection configurations. The independent variables for this experiment were the four intersections; 14th and Jefferson (signalized), 11th and Jefferson (unsignalized), 11th and Monroe (unsignalized), and 14th and Monroe (signalized). The dependent variables that were tested were the total number of glances left and right through each intersection, total number of glances behind before merging, time from the intersection of the first glance behind, time from the intersection of the lane merge, and time between the last glance and lane merge. This research tested three hypotheses.

1. $\boldsymbol{H_O}$: *There is no difference in the visual search task and behavior of bicyclists at intersections with different levels of control.*
2. $\boldsymbol{H_O}$: *There is no difference in the visual search task and behavior of experienced and non-experienced bicyclists at intersections.*
3. $\boldsymbol{H_O}$: *There is no difference in the visual search task and behavior of males and females at intersections.*

1.2 Organization of the Report

The report is organized as follows:

- Section 2 Literature Review – Relevant literature is reviewed and summarized.
- Section 3 Methodology – Procedure and methods are listed and described.
- Section 4 Results – Data analysis and results are presented.
- Section 5 Conclusion – Conclusion presented.

2 LITERATURE REVIEW

2.1 Introduction

Cycling represents a critical mode of travel in the United States. However, due to the overrepresentation of the vehicular mode of travel, many intersection designs favor motorists rather than bicyclists. Intersections are of particular concern because a significant share of mixed mode collisions, collisions between bicycles and vehicles, occur at road intersections, due in part to the increased number of conflict points. Along with the generally increased risk for bicyclists at intersections, those performing a left turn movement experience the greatest risk as they cross the path of a conflicting through movement at "significant speed differentials which can lead to serious injuries or fatalities" (*1*) due to right angle crashes.

The visual search patterns of bicyclists performing a left turn movement through an intersection are of particular interest. Knowledge of where bicyclists are looking while performing left turn movements provides traffic engineers information critical to the design of safer intersections in which bicyclists are able to obtain proper information in order to navigate the intersection safely. In order to successfully perform a left turn movement a bicyclist must detect other vehicles, bicyclists, and pedestrians as well as traffic signals, signs, and markings. The nature in which a bicyclist visualizes and maneuvers an intersection may vary depending on the intersection type. Three possible intersection types that bicyclists perform left turn movements at include permitted left turns on a circular green indication at a four-way signalized intersection, left turns in which the bicyclist is on the major roadway and turns left at a two way stop controlled intersection, and left turns in which bicyclists approach on the minor road and stops at a stop sign at a two way stop controlled intersection to turn left onto the major road. Each of these intersections requires bicyclists to perform a left turning movement while crossing oncoming traffic.

2.2 Safety

The potentially significant speed differential between a bicycle and motor vehicle, the lack of onboard safety systems for a bicyclist beyond a helmet, and the reduced visibility of a cyclist make them particularly vulnerable while proceeding through an intersection. With regards to road safety there is a greater crash risk when cycling as compared to driving or being a passenger in a motor vehicle (*2*). This is because bicyclists have significantly less protection from a crash compared with motor vehicle operators. There is also the concern that "the risk of being involved in a crash while cycling is typically higher than while traveling in a motor-vehicle, the key concern is the severity of injuries to cyclists" (*3*). There are multiple vehicular conflict paths that a bicyclist can encounter while performing a left turn movement through an intersection.

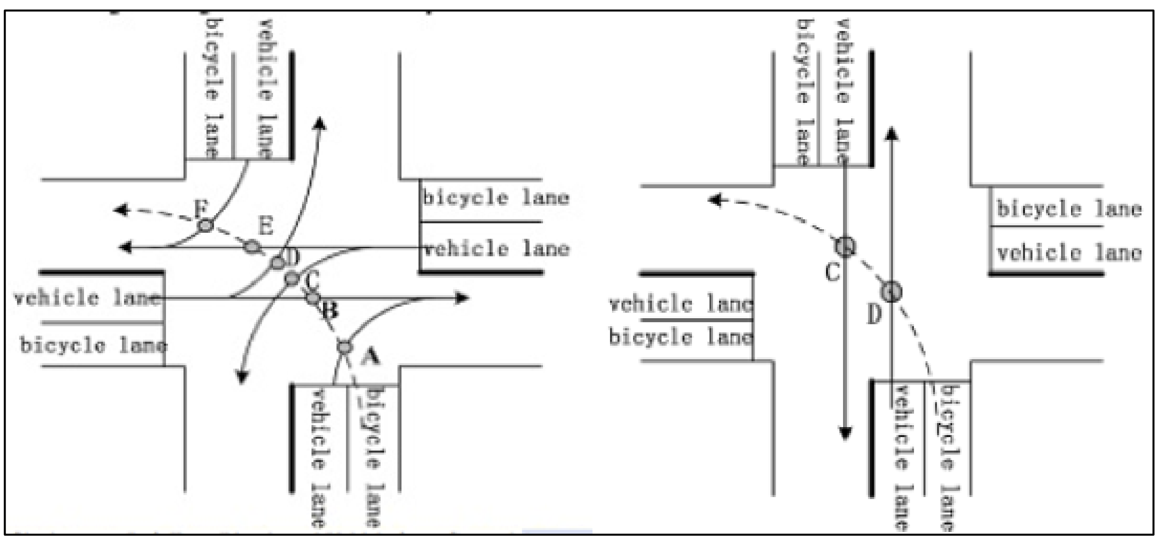

Figure 1: Conflict between Left Turn Bicycle and Vehicle from Crossed and Same Approach *(4)*

A bicyclist faces more conflict points when turning left at an intersection because they must not only avoid the vehicle in their same lane shown as conflict A on the left and conflict D on the right in Figure 1 but they must also avoid potential conflict points with vehicles within the intersection and pedestrians in the conflicting crosswalks. The combination of the two left turning scenarios in Figure 1 reveals that there are eight possible conflict points for a bicyclist turning left at an intersection. These conflict points help to elaborate the risk involved with a bicyclist turning left at an intersection.

2.3 Behavior

Field observations showed that the movement of bicycles at signalized intersections is quite different from that of motor vehicles (*5*). While performing left turn movements, “cyclists seem to need a longer gap and lag” (*6*) time in order to maneuver through the intersection. This is because bicyclists are unable to complete the turn as fast as vehicles thus increasing the amount of time spent in the functional area of an intersection. Research has also revealed that “cyclists are frequently observed committing road-rule violations at intersections leading to an increase in safety risks, and most bicycle crashes at intersections occur as a result of failure to yield” (*7*). By committing road-rule violations bicyclists are increasing their exposure to traffic. Although these intersections are not necessarily unsafe, the “more interactions between bicyclists and motorists can indicate a higher level of bicyclist exposure to vehicle traffic and, therefore, a generally higher chance of encountering risky situations” (*8*).

There are two types of bicycle-motor vehicle (BMV) crashes: type I and type II. A type I crash describes the bicyclist having the right of way while a type II crash describes the motorist having the right of way. In type I crashes cyclists often noticed the driver before the accident while few drivers recognized the bicyclist (*9*). In type II crashes, bicyclists cross the major roadway and rarely did anything to avoid the crash while drivers often did something (*9*).

2.4 Crash Data

Bicyclists face disproportionate dangers on the Nation's roadways. Based on 2008 data from NHTSA's Fatality Analysis Reporting System, "270 (or 3.5 percent) of the 7,772 intersection fatalities were bicyclists" *(10).* This is of concern because "bicycle trips accounted for less than one percent of all trips in 2008" *(10).* This number increased to 277 bicyclist fatalities (3.6 percent) of the 7651 intersection fatalities in 2012 (*11).* Figure 2 reveals all possible crash patterns associated with a left turn.

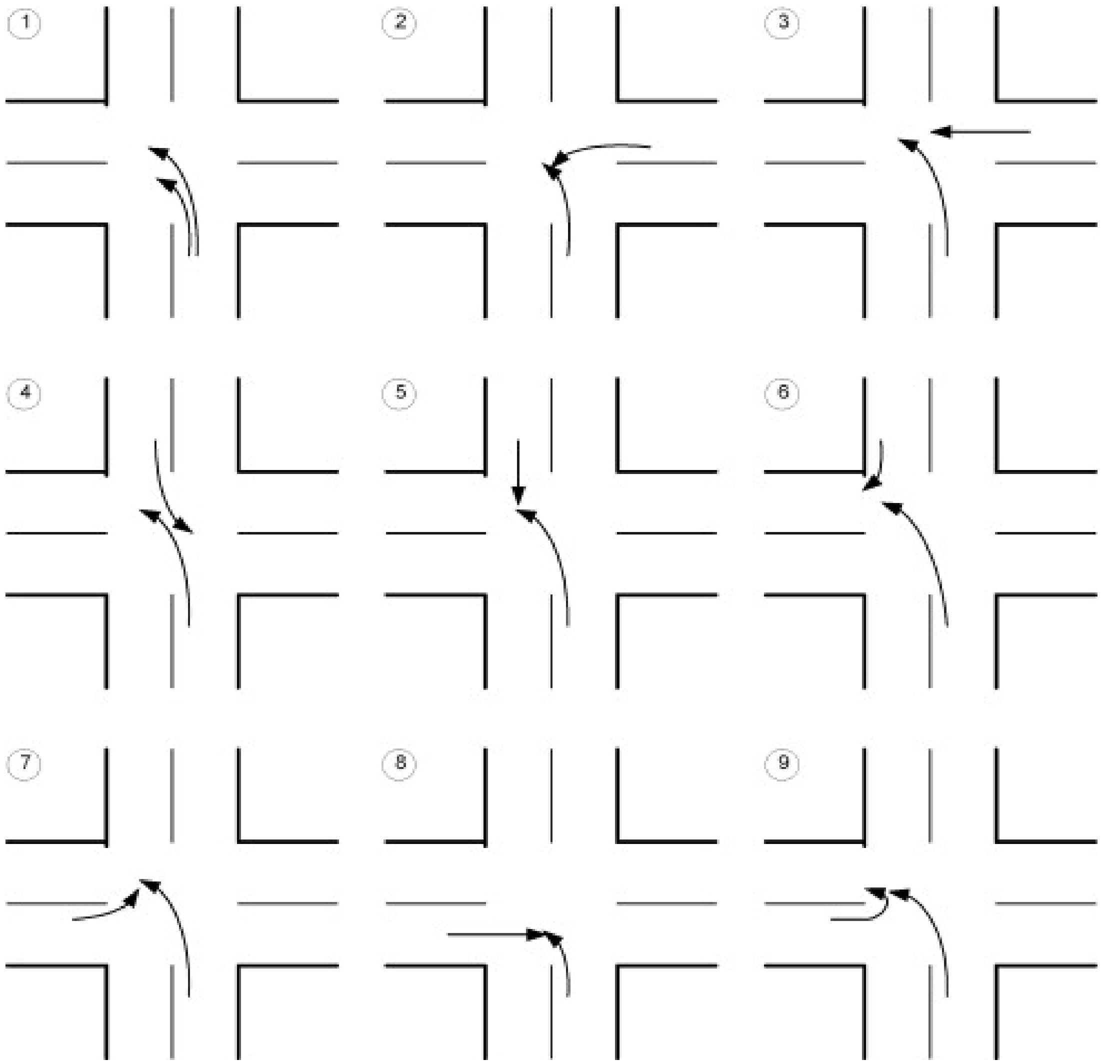

Figure 2: Left Turn Crash Patterns Classified by Conflicting Vehicle Maneuvers (*12*)

One study revealed, “out of 3098 left turn crashes, 2245 were associated with crash pattern five and 437 crashes were associated with pattern eight” *(12)*. That accounts for 72.5% of the total left turn crashes with the next most significant case, pattern eight, equating to 14.1%. This data was specifically for vehicle crashes, but bicyclists face the same conflicts while turning left at an intersection. The pattern five crash type is also particularly dangerous for bicyclists because the vehicle and bicycle crash head on. Each user is moving in opposite directions thus increasing the severity of impact. Crash patterns one, four, and nine in Figure 2 above are not found in Figure 1. Conflict points A on the left and D on the right in Figure 1 are not found in Figure 2 because these conflict points are created from the vehicle lane adjacent to the bicyclist lane. The combination of Figure 1 and Figure 2 reveals a total of 11 conflict points associated with bicyclists turning left through an intersection.

Bicycle crashes tend to be more concentrated at intersections where motor vehicle and bicycle volumes tend to be higher and there are more frequent opportunities for traffic conflicts between these road users (*13*). According to Traffic Safety Factors 2000, “32.6% of fatal accident and 56.6% of injury BMV collisions occurred at intersections in the US” (*14*). Intersections are one type of transportation facility where bicyclists and motor vehicles must interact. For a bicyclist to safely perform a left turn movement, they must detect the speed and position of vehicles as well as the position and meaning of signs signals and pavement markings.

2.5 Effective Measures

Traffic engineers are responsible for making intersections safe for vehicles, bicyclists, and pedestrians. It is apparent that bicyclists are at greater risk while traveling through intersections, which motivates traffic engineers to mitigate this risk through improved design and operations. Analyzing left turning bicycle traffic is critical for improving intersection operation and safety *(12).* In particular, there is a safety concern for bicyclists taking a left turn through an intersection due to increased exposure to motor vehicles. Marked cycle lanes, longer signal lengths and intersections with bicycle lanes, among many other strategies have the potential to increase bicycle safety at intersections.

Since most “collisions between bicycles and cars occur at road intersections,” (*15*) traffic engineers are continually looking for ways to safely design intersections for motor vehicles, bicycles, and pedestrians. The safety of an intersection is a function of traffic volume, several geometric factors, and the type of signalization (*8*). Therefore, traffic engineers need to effectively balance the several factors that influence the safety of an intersection for motorists, bicyclists, and pedestrians. In regards to bicyclists, “the total width of the outside through lane and the intersection crossing distance were found to be the primary factors influencing bicyclists’ safety and comfort at intersections” (*8*). A bicyclist can visually detect both the outside lane width and intersection crossing distance as they approach an intersection.

It is difficult in many cases for traffic engineers to balance motorists, bicyclists, and pedestrian safety at intersections. The addition of “onstreet bicycle lanes are better for cyclists at intersections because drivers can expect to encounter them, but, on the other hand, onstreet lanes can lead to more onroad conflicts” (*16*). This makes it difficult to safely design intersections for all three modes. An effective measure to prevent BMV crashes is to use speed-reducing measures for drivers entering or leaving the main road (*9*). This means that one way to increase bicyclist safety is to focus on reducing the behavior of motor vehicles through an intersection.

3 METHODOLOGY

There have been numerous studies regarding the behavior of bicyclists and motor vehicles as they interact on the roadway. However, there is little information regarding the visual search patterns of bicyclists and how these search patterns influence their behavior in response to motor vehicles. This research focused on the visual search patterns and behavior of bicyclists performing a left turn at intersections with varying levels of control. In order to conduct this research, subjects were equipped with a mobile-eye tracking device and told to navigate a pre-determined course that encompassed four different intersection designs at which they were required to turn left. During each left-turn maneuver, the visual search tasks and general behavior of each subject was recorded.

3.1 Research Design

Within the pre-determined course, there were four unique intersection configurations. These four intersections and approaches to the intersections were the primary concern of the observations. The subjects were told to perform left turn maneuvers at the intersections as they normally would. Figure 3 highlights the layout of the course the subjects were asked to bicycle. The four intersections were traversed by the subjects in the following order: 1) 14^{th} and Jefferson, 2) 11^{th} and Jefferson, 3) 11^{th} and Monroe, and 4) 14^{th} and Monroe.

Figure 3: Overview Layout of Course

A variety of dependent variables were considered in this research, as listed below:

1. Number of looks left and right through the intersection.
2. Total number of glances behind.
3. Time away from intersection when the bicyclist first glances behind to merge.
4. Time away from intersection when the bicyclist merges lanes to turn left.
5. Time between the last glance behind and lane merge.

With the use of these questions, the following hypotheses were tested.

1. ***H_O**: There is no difference in the visual search task and behavior of bicyclists at intersections with different levels of control.*
2. ***H_O**: There is no difference in the visual search task and behavior of experienced and non-experienced bicyclists at intersections.*
3. ***H_O**: There is no difference in the visual search task and behavior of males and females at intersections.*

The first hypothesis tests the differences between signalized and unsignalized intersections with regard to the visual search pattern and behavior of bicyclists, as they turn left. The second hypothesis focused on the differences between experienced and novice bicyclists and whether or not experience plays a role in the visual search patterns of bicyclists. Finally, the third hypothesis tests the effects of gender on how one allocates their visual attention while navigating a left turn.

The course encompassed four intersections, each with a unique layout and design. The five dependent variables that were considered were total number of looks left and right, total number of glances behind, time away from the intersection when the bicyclist first glances back to merge, time away from the intersection when the bicyclist merges, and time between the last glance and lane merge. Each of these dependent variables were tested with the above three hypotheses.

3.2 Subject Recruitment and Sample Size

Participants involved within this study were selected from among OSU students. Subjects were required to not have vision problems and to be capable and comfortable operating a bicycle on campus roads. They were also evaluated on whether or not they were competent to provide written, informed consent. The recruitment of participants was accomplished through the use of flyers posted around campus, as well as announcements during various civil engineering classes. Before the experiment took place, the appropriate documentation was provided to the OSU IRB, and was subsequently approved (study 5561).

This study was completed with the help of 18 participants. Researchers did not screen interested participants based on gender. The average age of participants was relatively low at 22.4 years. Subjects were targeted to be within the ages of 18 to 75, however all subjects fell within the 20 to 26 range. Depending on the intersection and individual, a few subjects maneuvered the intersection in a way that limited the use of their data such as using crosswalks or crossing traffic in an uncharacterized manner. Other demographic information of the subject population is show in Table 1.

There was an overrepresentation of males to females (12 to six) within the experiment. No participant selected his or her experience as beginner and only one participant selected expert. This disparity limits the range of experience down to the central three options of novice, intermediate, and advanced.

Table 1: Subject Summary Demographics

Gender		
Possible Responses	*Number of Participants*	*Percent of Participants*
Male	12	66.7%
Female	6	33.3%
Experience		
Beginner	0	0.0%
Novice	7	38.9%
Intermediate	6	33.3%
Advanced	4	22.2%
Expert	1	5.6%
How many miles do you walk weekly?		
$0 \leq 5$	5	27.8%
$6 \leq 10$	5	27.8%
$11 \leq 15$	5	27.8%
$16 \leq 20$	0	0.0%
20+	3	16.7%
How many miles do you bike weekly?		
$0 \leq 10$	10	55.6%
$11 \leq 20$	4	22.2%
$21 \leq 30$	2	11.1%
30+	2	11.1%
How many miles do you drive weekly?		
$0 \leq 20$	7	38.9%
$21 \leq 40$	4	22.2%
$41 \leq 60$	3	16.7%
$61 \leq 80$	1	5.6%
80+	3	16.7%
Age		
Minimum	*Average*	*Maximum*
20	22.4	26

3.3 Procedure

Participants were invited to arrive at Owen Hall located on the Oregon State Campus. Upon arriving, the participants were given the informed-consent document, provided a verbal summary of the document by a student researcher, and given the chance to review and sign the document.. Participants were informed of the potential risk of riding their bicycles in live traffic as well as the danger of merging into the traffic lane. After the informed consent, students participated in a demographic survey.

After completing the consent form and demographic questionnaire, participants were equipped with a helmet for safety and were then calibrated with the mobile eye-tracking device. After receiving calibration, they were lead outside to retrieve their bicycles and provided additional opportunity to ask any last questions regarding the test and layout. Subjects were instructed to behave naturally while bicycling and follow all traffic laws. After completing the test, the subjects would return the mobile eye-tracking device.

3.4 Eye Glance Data

Eye-tracking data was collected by the Mobile Eye-XG platform from Applied Science Laboratories (Figure 4**).** This platform allows the user to have both unconstrained head and eye movement, generating a sampling rate of 30 Hz and an accuracy of 0.5 to 1.0 degree. The mobile eye-tracking device was suitable for this research because the platform can be held within a backpack and taken with the subjects as they rode their bicycles. After performing the test, subjects returned the mobile eye-tracking device and the data was uploaded into Applied Science Laboratories programs and analyzed.

Figure 4: OSU Researcher Demonstrating Both the Mobile Eye XG Glasses and Mobile Recording Unit

3.5 Layout and Intersection Designs

The overall course required each subject to turn left through four separate intersections. This course was selected because of its close proximity to campus, the overall time to complete the course being between three to seven minutes, and the variety of intersection designs that were encompassed. The four intersections are located at 14th and Jefferson, 11th and Jefferson, 11th and Monroe, and 14th and Monroe.

3.5.1 First Intersection: 14th and Jefferson

The subject begins by proceeding down 14th street before arriving at the first intersection, 14th and Jefferson. This four-way signalized intersection was of interest due to the relatively high pedestrian and vehicle traffic. Figure 5 details the lane layout and traffic signal displays associated with this intersection. This intersection used a permitted left turn on a circular green indication with an exclusive left turn lane and a shared through right turn lane. The participant must transfer from the bike lane on the right side of the street to the left turning lane in the middle of the street to perform the left turn safely. If the bicyclist is uncomfortable merging lanes, they may choose to use the crosswalk instead.

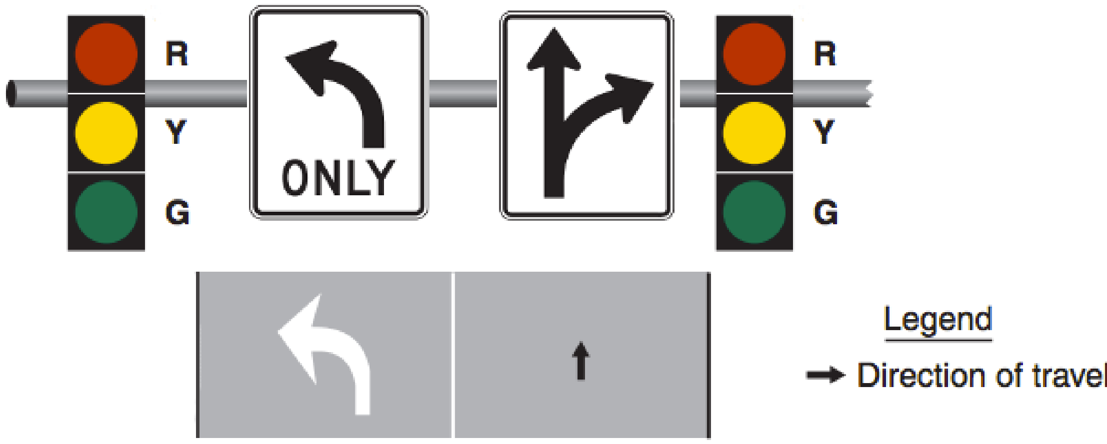

Figure 5: Intersection Design at 14th and Jefferson ***(17)***

After entering the left turning lane, the bicyclist then assumed the role of a traveling vehicle and obeys all laws that a vehicle would in that situation. The signalized intersection approach at 14th and Jefferson, as seen in Figure 6, used a permitted left turn in which the bicyclist yields to oncoming traffic and pedestrians. The bicyclist must not only pay attention to oncoming traffic, but also focus on pedestrians crossing the street and cars in front or behind them. When traffic permits, the bicyclist makes a left at this intersection to arrive onto Jefferson Street.

Figure 6: Intersection of 14th and Jefferson

3.5.2 Second Intersection: 11th and Jefferson

After navigating the intersection of 14th and Jefferson, the participants maneuvered into the bike lane on Jefferson Street and continue traveling the street. They traveled down Jefferson Street until reaching the intersection of 11th and Jefferson. This intersection has a different layout from the previous intersection in that this intersection is two-way stop controlled in which the bicyclist had the option to navigate the turn without stopping, if traffic permitted. Figure 7 shows the two-way stop controlled intersection located on 11th and Jefferson.

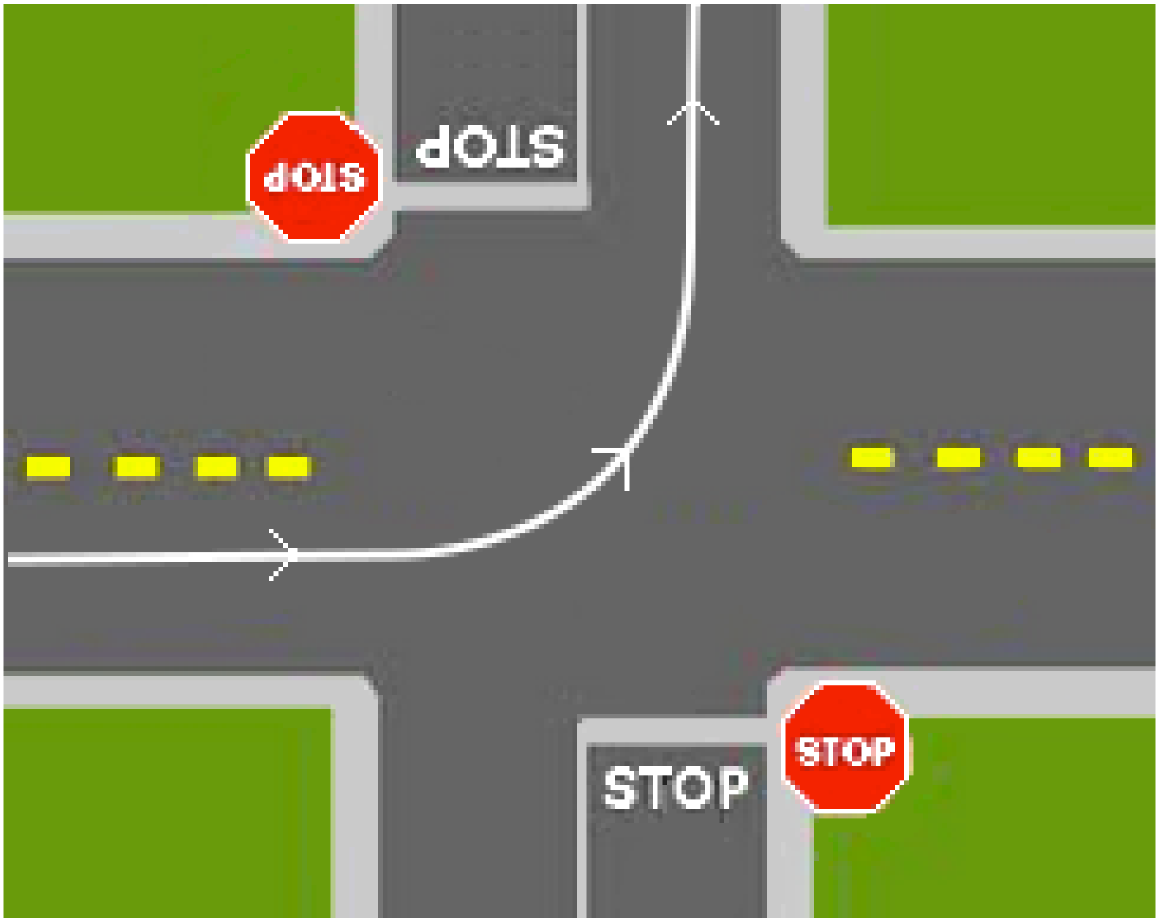

Figure 7: Intersection Design at 11th and Jefferson (*18)*

The participant approached the intersection of 11th and Jefferson, as seen in Figure 8, in where they turned left onto 11th street. This intersection is another point of interest because the bicyclist has to safely watch oncoming traffic while obeying all traffic laws. They must first signal a turn, watch oncoming traffic, check for pedestrians, and then safely turn left onto 11th street.

Figure 8: Intersection of 11th and Jefferson

3.5.3 Third Intersection: 11th and Monroe

After turning onto 11th Street, the bicyclist traveled towards Monroe Street. 11th street is interesting because the bicyclist was required to behave as a vehicle because there is no bike lane and on street parking is allowed on both sides. This reduction in road width required more concentration from the rider in order to safely avoid cars. Once the bicyclist traveled down 11th street, they approached the stop sign to turn onto Monroe Street. Figure 9 shows the two-way stop controlled intersection located on 11th and Monroe in which the bicyclist approached on the minor road and stopped at a stop sign in order to turn onto the major road. This is the third area of interested because this intersection, which is similar to the second intersection, is a 2-way stop, however this time the bicyclist used the stop sign before turning left. A street view is shown in Figure 10.

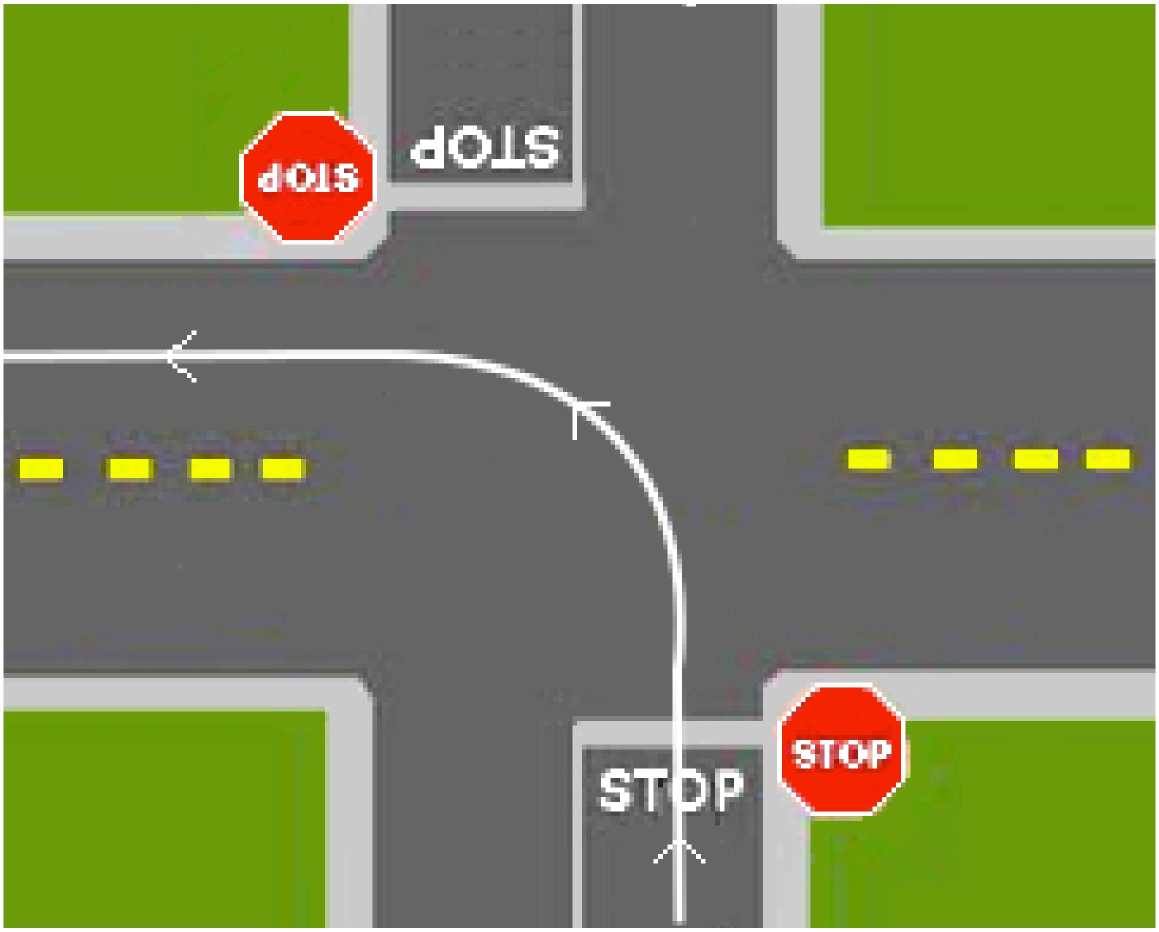

Figure 9: Intersection Design at 11th and Monroe (*18)*

Figure 10: Intersection of 11th and Monroe

3.5.4 Fourth Intersection: 14th and Monroe

Once the bicyclist navigated the left turn onto Monroe Street, they worked into the bike lane traveling toward the final intersection at 14th and Monroe. Figure 11 is a permitted left turn on a circular green indication located on 14th and Monroe, similar to the first intersection on 14th and Jefferson. This intersection however used a different sign and striping layout when compared with the intersection of 14th and Jefferson. Figure 12 details the approach to the intersection of 14th and Monroe.

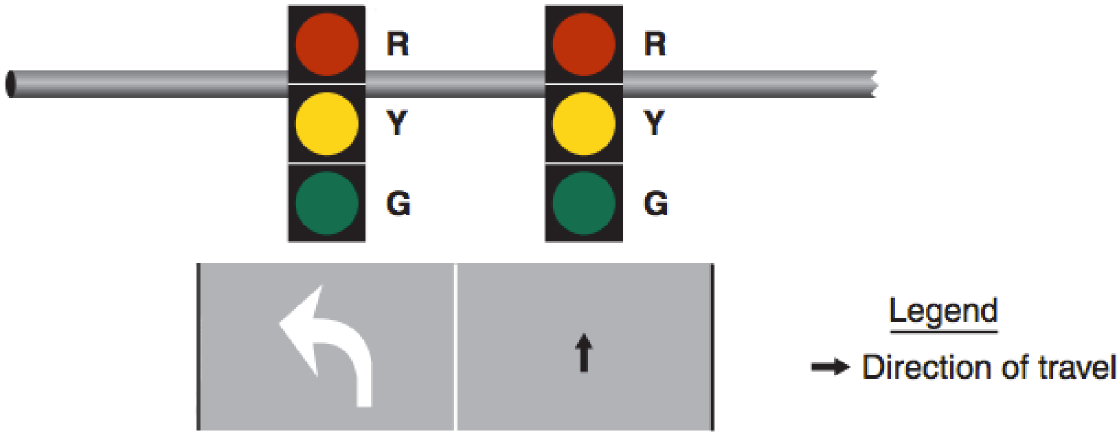

Figure 11: Intersection Design at 14th and Monroe ***(17)***

Figure 12: Approach of Intersection at 14th and Monroe

4 RESULTS

4.1 Data Reduction

The three hypotheses tested were:

1. ***H_O**: There is no difference in the visual search patterns of bicyclists at intersections with different levels of control.*
2. ***H_O**: There is no difference in the visual search task and behavior of experienced and non-experienced bicyclists at intersections.*
3. ***H_O**: There is no difference in the visual search task and behavior of males and females at intersections.*

After the experiment, a list of questions were developed and listed below as the dependent variables:

1. How many times does the subject look left and right through an intersection?
2. How many total times does the subject glance back?
3. How much time before approaching the intersection does the subject have when they glance back?
4. How much time before approaching the intersection does the subject have when they merge lanes?
5. How much time elapses between the last glance back and the lane merge?

Within these questions, comparisons were made between each intersection as well as comparisons between experience and gender. Each hypothesis was tested for each dependent variable for validation or rejection. Questions 3, 4, and 5 regarding time were divided among intersections. The reason time was measured instead of distance is due to the drastically different riding styles between subjects as some subjects rode much faster than others. 14th and Jefferson, 11th and Jefferson, and 14th and Monroe were tested because the intersection of 11th and Monroe did not provide sufficient data. Out of 18 participants, only six choose to glance behind them as they approached that intersection. Due to this disparity, the intersection of 11th and Monroe was left out of the analysis regarding time.

4.2 Left and Right Glances

How often a bicyclist looks left and right when turning left at an intersection is critical because these glances allow them to scan their surroundings and reduce the likelihood of a crash. The authors postulate that the more a bicyclist looks left and right through an intersection, the more cautious they are. After the data was reduced, comparisons were made between each intersection, experience, and gender.

4.2.1 Left and Right Glances vs. Intersections

For the first set of statistical analysis, the number of glances left and right while turning left was compared for each intersection. This correlates with the first null hypothesis found in Section 3.1

> ***H_O****: There is no difference in the visual search task and behavior of bicyclists at intersections with different levels of control.*

The number of looks left and right was calculated for each intersection, as shown in Figure 13.

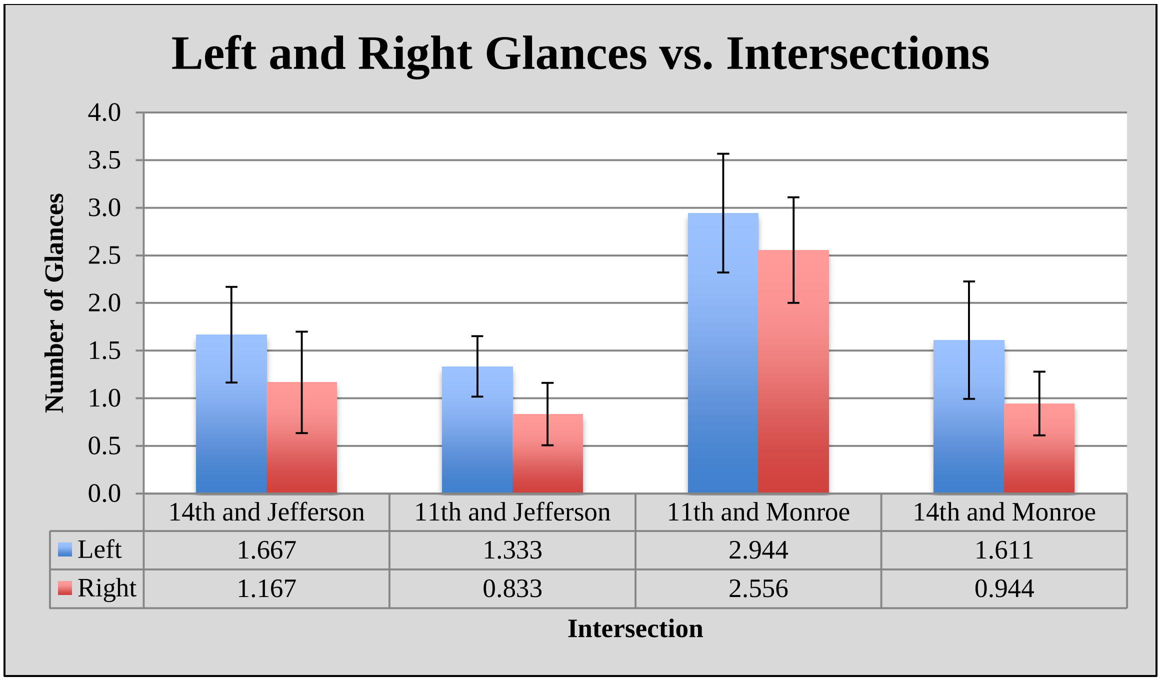

Figure 13: Average Number of Left and Right Glances vs. Intersections with 95% CI

In all four intersections, subjects looked left an average of 0.5 times more than they looked right. Specifically the intersections of 14th and Jefferson, 11th and Jefferson, and 14th and Monroe all prove significantly different than 11th and Monroe because the 95% CIs for looking left do not overlap. This graphical representation suggests that bicyclists, when turning left, look left more often than right, however the overlapping CIs do not validate this statistically. To further validate the observation that bicyclists look left more often when turning left, a two-tailed t-test assuming unequal variance was conducted as seen in Table 2. Only the intersection of 11th and Jefferson resulted in a p-value of less than 0.05, as shown in bold in Table 2, proving statistically significant. This was the first unsignalized intersection where the bicyclist had the right of way. There is not enough statistical evidence to suggest that bicyclists look left or right more within the other three intersections. An ANOVA analysis was conducted in order to test the differences between all intersections. The p-value was less than 0.05, proving that there are differences amongst intersections in regards to looking left or right. However, this ANOVA analysis does not specify which intersections are different. Therefore, the intersections were then compared by left and right glances separately to identify differences between intersection designs.

Table 2: Analysis of Left vs. Right Glances

Intersection	Left vs. Right
	P-Value
14th and Jefferson	0.189
11th and Jefferson	**0.038**
11th and Monroe	0.367
14th and Monroe	0.071
ANOVA	<**0.001**

In order to compare intersections, a two-sample t-test assuming unequal variance was conducted Table 3. Each of the four intersections was compared with each other to see if any intersections proved statistically significant from one another. Interestingly, the intersection of 11th and Monroe proved statistically significant from all three other intersections. This intersection requires the bicyclist to stop and focus on traffic from both the right and left directions, thus causing more uncertainty and therefore more glances.

An ANOVA analysis was also analyzed in order to test overall differences between each intersection. Both left and right glances provided a p-value below 0.05, thus statistically significant. This matches the t-test analysis since the intersection of 11th and Monroe proved statistically different from all other intersections.

Table 3: Analysis of Left and Right Glances vs. Intersections

Intersections	**Glance Direction**	
	Left	Right
	P-Value	
14th and Jefferson and 11th and Jefferson	0.278	0.302
14th and Jefferson and 11th and Monroe	**0.004**	**<0.001**
14th and Jefferson and 14th and Monroe	0.892	0.493
11th and Jefferson and 11th and Monroe	**<0.001**	**<0.001**
11th and Jefferson and 14th and Monroe	0.438	0.645
11th and Monroe and 14th and Monroe	**0.005**	**<0.001**
ANOVA	**<0.001**	**<0.001**

As a result, given the statistical differences associated with the intersection of 11th and Monroe regarding left and right glances through the intersection compared with all other intersections, it can be concluded that the null hypothesis suggesting no difference in visual search patterns of bicyclists at intersection of different levels of control can be rejected.

4.2.2 Left and Right Glances vs. Experience

In order to test the next hypothesis listed below, the total number of left and right glances were categorized by experience and compared with each intersection.

$\boldsymbol{H_O}$: *There is no difference in the visual search task and behavior of experienced and non-experienced bicyclists at intersections.*

These results can be found within Figure 14 and Figure 15 listed below.

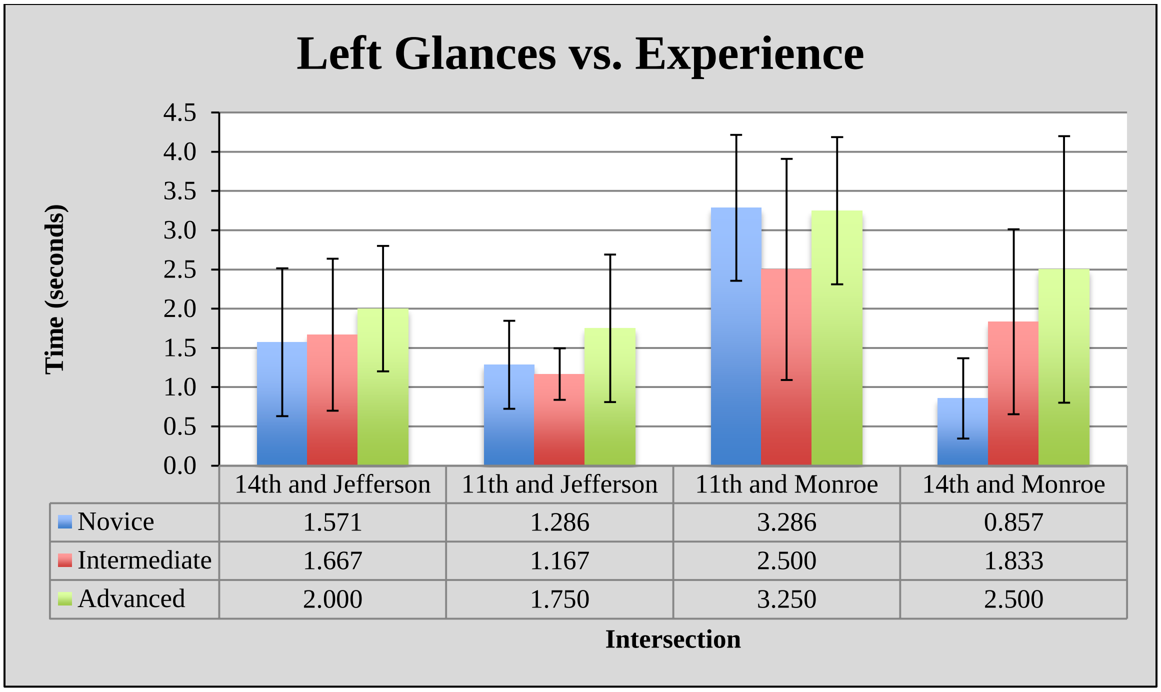

Figure 14: Left Glances vs. Experience with 95% CI

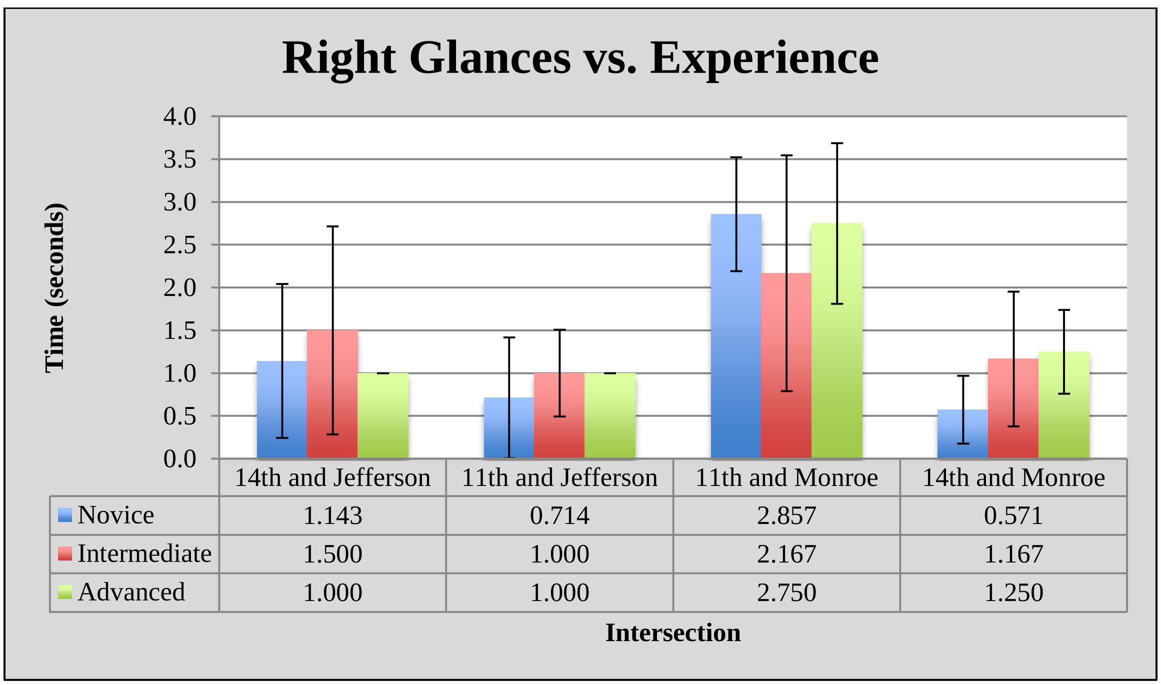

Figure 15: Right Glances vs. Experience with 95% CI

The two signalized intersections (14th and Jefferson and 14th and Monroe) both exhibited a positive correlation of left glances and experience. The two unsignalized intersections (11th and Jefferson and 11th and Monroe) both had the lowest number of glances occur with the intermediate experience. It should be noted that in all intersections, except 11th and Monroe, the highest amount of left glances occurred from advanced bicyclists.

Regarding right glances, there seems to be little to no consistency when compared with experience. Novice bicyclists glanced right more at 11th and Monroe, intermediate bicyclists glanced right more at 14th and Jefferson, and advanced bicyclists glanced right more at 14th and Monroe.

In order to statistically test if experience changes the number of left and right glances through an intersection, a two-tailed t-test assuming unequal variance was conducted and shown in Table 4. Graphically, there seem to be statistical differences when associated with experience, however, the t-tests do not provide any sufficient data to suggest any statistical findings. This can be attributed to the low number of participants within each experience level. There were seven novice riders, six intermediate, and four advanced. The relatively low number of data makes it difficult to provide any significant statistical findings. An ANOVA analysis was also conducted. Similar to the t-test comparison, there were no statistically significant p-values. As a result, there is not enough information to reject the null hypothesis suggesting no difference in visual search patterns of bicyclists regarding experience.

Table 4: Analysis of Left and Right Glances vs. Experience

Intersection	Left or Right	Comparison			
		ANOVA	Novice and Intermediate	Novice and Advanced	Intermediate and Advanced
		P-Value			
14th and Jefferson	Left	0.840	0.893	0.515	0.617
	Right	0.789	0.653	0.766	0.456
11th and Jefferson	Left	0.441	0.727	0.442	0.318
	Right	0.734	0.533	0.457	1.000
11th and Monroe	Left	0.569	0.386	0.959	0.411
	Right	0.604	0.405	0.861	0.513
14th and Monroe	Left	0.138	0.181	0.152	0.551
	Right	0.241	0.224	0.074	0.865

4.2.3 Left and Right Glances vs. Gender

In order to test the next hypothesis listed below, the total number of left and right glances were categorized by gender and compared with each intersection.

$\boldsymbol{H_O}$: *There is no difference in the visual search task and behavior of males and females at intersections.*

These results can be found within Figure 16 and Figure 17 listed below.

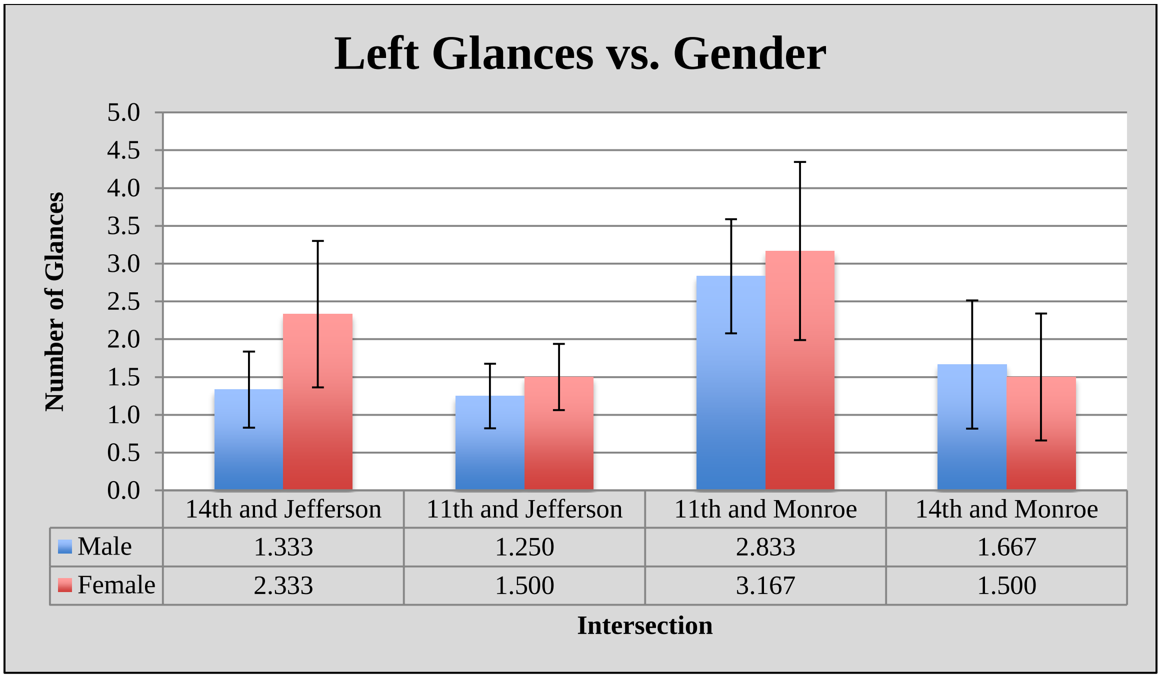

Figure 16: Left Glances vs. Gender with 95% CI

In all but one intersection (14th and Monroe), females glanced left more than men. This possibly suggests that females exhibit more caution when turning through an intersection.

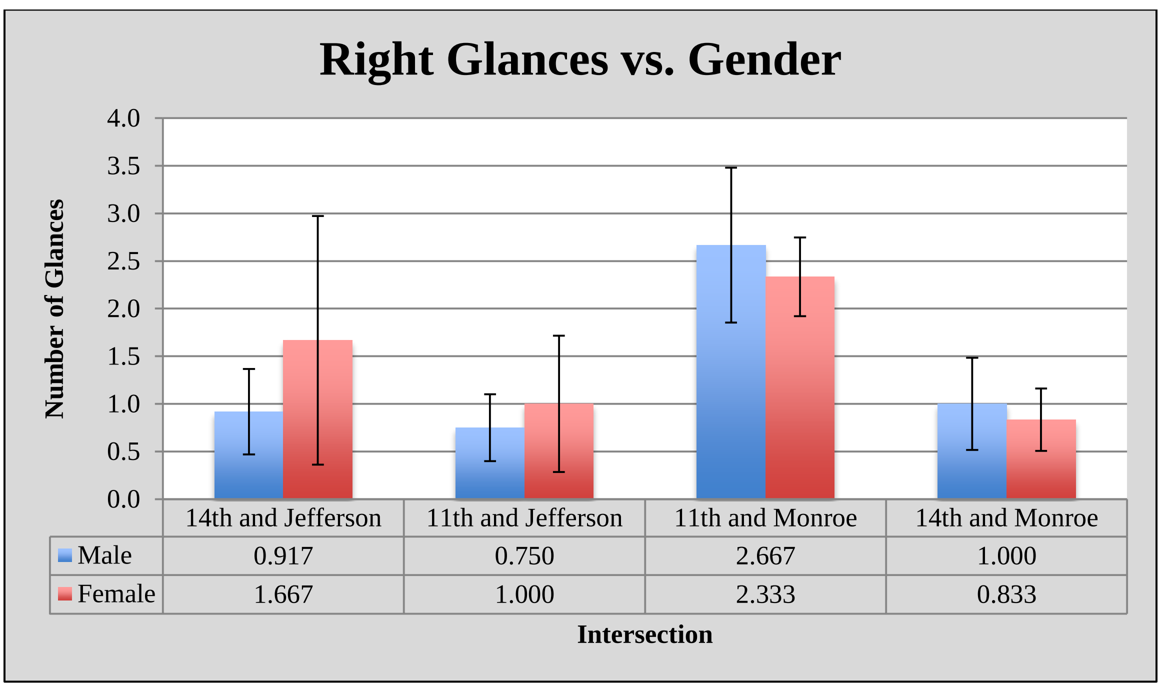

Figure 17: Right Glances vs. Gender with 95% CI

Regarding right glances, females glanced right more at the first two intersections whereas males glanced right more in the last two intersections. This makes it difficult to see any statistical significance because both males and females glance right more in one signalized and one unsignalized intersection.

Graphically, it is difficult to conclude whether or not males or females glance left or right. To see if any statistical differences exist between male and female, a two-tailed t-test assuming unequal variance was conduct and shown in Table 5. Statistically, there are no comparisons significant enough to provide a p-value of less than 0.05. Despite within the first intersection of 14th and Jefferson with females looking left 2.33 times compared to males 1.33 times, there is not enough statistical evidence to suggest that males and females exhibit differences when glancing left or right. This may be due to the fact that there were 12 males and only six females. It the data was more proportionate, it could be possible to see statistical differences. However, there is not enough evidence to reject the null hypothesis suggesting there is no difference in the visual search patterns of males and females.

Table 5: Analysis of Left and Right Glances vs. Gender

Intersection	**Left or Right**	**Comparison** Male and Female P-Value
14th and Jefferson	Left	0.111
	Right	0.327
11th and Jefferson	Left	0.437
	Right	0.557
11th and Monroe	Left	0.651
	Right	0.484
14th and Monroe	Left	0.788
	Right	0.583

4.3 Total Number of Glances

How often a bicyclist looks back can be directly correlated with safety. The act of looking back before merging allows the bicyclist to visually address the vehicle traffic in their travel lane. This perception allows them to address where and possibly how fast vehicles are traveling in order to safely merge into the travel lane. It can be assumed that the more often a bicyclist glances back, the more cautious they are.

4.3.1 Total Number of Glances vs. Intersections

For the first set of statistical analysis, the total number of glances back was compared with each intersection. These results are shown in Figure 18 below. This correlates with the first null hypothesis found in Section 3.1

> $\boldsymbol{H_O}$: *There is no difference in the visual search patterns of bicyclists at intersections with different levels of control.*

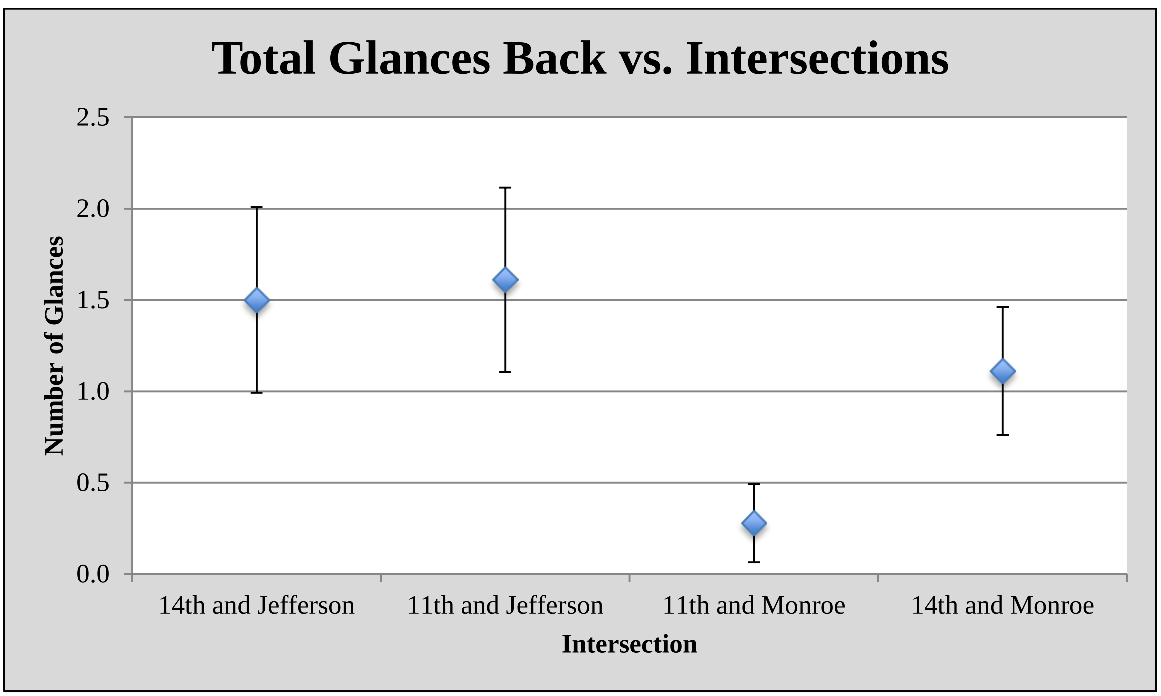

Figure 18: Total Glances Back vs. Intersections with 95% CI

Graphically, it can clearly be seen that subjects glance back far fewer times at the intersection of 11^{th} and Monroe, making this intersection an outlier. The approach to this intersection varies drastically in design from the other intersections. Unlike all the other intersections, the approach to 11^{th} and Monroe does not have any bike lane. There is also parking allowed on both sides of the street greatly reducing the width of the road. This reduction forces bicycles to act as a vehicle and ride in the vehicle lane. The fact that the bicyclist is already in the vehicle lane decreases the likelihood of glancing back because there is no merge needed. The bicyclist also feels security being in the vehicle lane because a car is unable to pass them due to the restricted width of the road. In order to see if any statistical differences exist, a two-tailed t-test with unequal variance was performed comparing the mean number of glances back at each intersection. These results can be found in Table 6.

Table 6: Analysis of Total Glances Back vs. Intersections

Intersections	P-Value
14th and Jefferson and 11th and Jefferson	0.763
14th and Jefferson and 11th and Monroe	**<0.001**
14th and Jefferson and 14th and Monroe	0.226
11th and Jefferson and 11th and Monroe	**<0.001**
11th and Jefferson and 14th and Monroe	0.121
11th and Monroe and 14th and Monroe	**<0.001**
ANOVA	**<0.001**

Statistically significant p-values less than 0.05 were bolded in the table above. It becomes evident that the different intersection approach at 11^{th} and Monroe drastically changes how a bicyclist glances while approaching the intersection. All other intersections when compared with 11^{th} and Monroe provided significant p-values suggesting that there are differences regarding total glances back between intersections.

This was also validated using an ANOVA analysis resulting in a p-value below 0.05. This information is conclusive enough to reject the null hypothesis that there is no difference in the visual search patterns of bicyclists at intersections of different levels of control.

4.3.2 Total Number of Glances vs. Experience

In order to test the next hypothesis listed below, the total number glances back were categorized by experience and compared with each intersection.

***H_O**: There is no difference in the visual search task and behavior of experienced and non-experienced bicyclists at intersections.*

These results can be found within Figure 19 listed below.

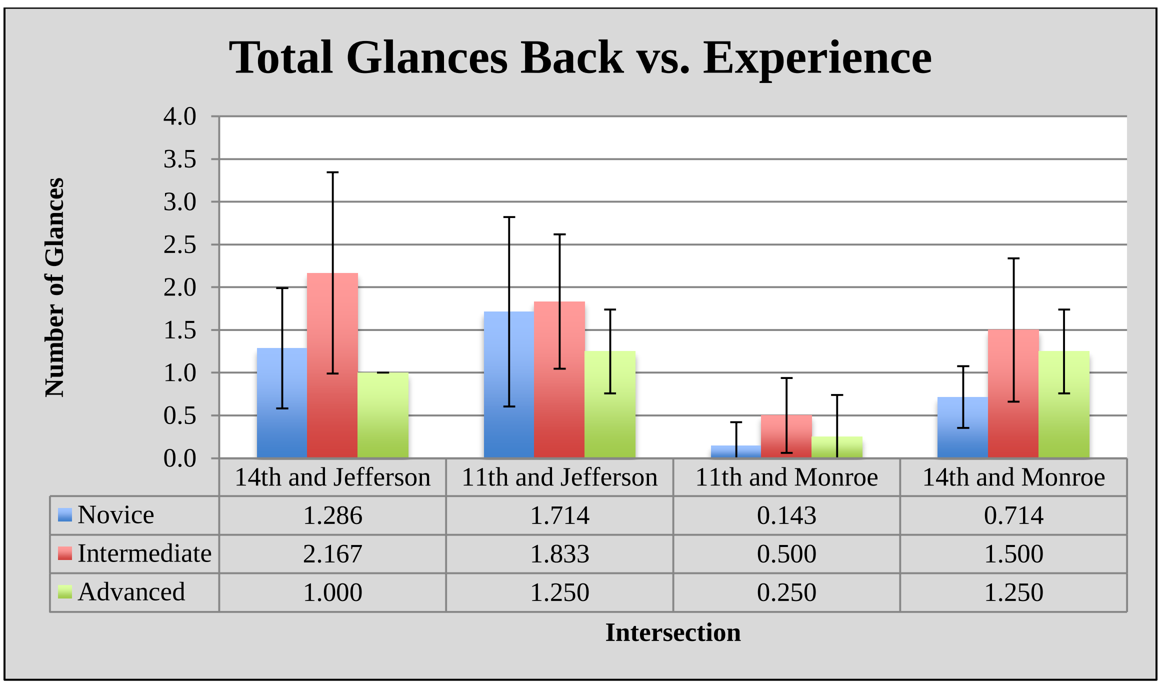

Figure 19: Total Glances Back vs. Experience with 95% CI

Graphically, it seems consistent that those who classified as intermediate glance back more through each intersection. This is the case in all four-intersection types.

However, it is less consistent regarding novice and advanced. In the first two intersections, novice bicyclists glanced back more while in the last two intersections, advanced bicyclists glanced more. To provide statistical reasoning, two-sample t-tests were conducted with unequal variance. These values can be found within Table 7.

Table 7: Analysis of Total Glances Back vs. Experience

Intersection	Comparison			
	ANOVA	Novice and Intermediate	Novice and Advanced	Intermediate and Advanced
	P-Value			
14th and Jefferson	0.216	0.242	0.457	0.110
11th and Jefferson	0.731	0.867	0.474	0.254
11th and Monroe	0.410	0.212	0.725	0.480
14th and Monroe	0.186	0.137	0.134	0.629

Using the results of the t-test, there were no statistically significant differences regarding glances back and experience. The closest difference came at the first intersection of 14th and Jefferson and was the comparison of intermediate and advanced bicyclists. The average number of glances back for intermediate bicyclists was 2.167 seconds, and the average number of glances back for advanced bicyclists was 1.0 seconds. Despite a 1.167 second increase of glances from advanced to intermediate; there is not enough of a difference to prove significant. This can be contributed to the small data set. Within the test, only seven answered novice, six intermediate, and four advanced. In order to further test if there was any significance, an ANOVA analysis was conducted for each intersection. Similar to the t-test analysis, there were no statistically significant p-values below 0.05. Due to the high p-values, there is not enough evidence to reject the null hypothesis that there is no difference in the visual search patterns of bicyclists turning left when compared with experience.

4.3.3 Total Number of Glances vs. Gender

In order to test the next hypothesis listed below, the total number glances back were categorized by gender and compared with each intersection.

H_O*: There is no difference in the visual search task and behavior of males and females at intersections.*

These results can be found within Figure 20 listed below.

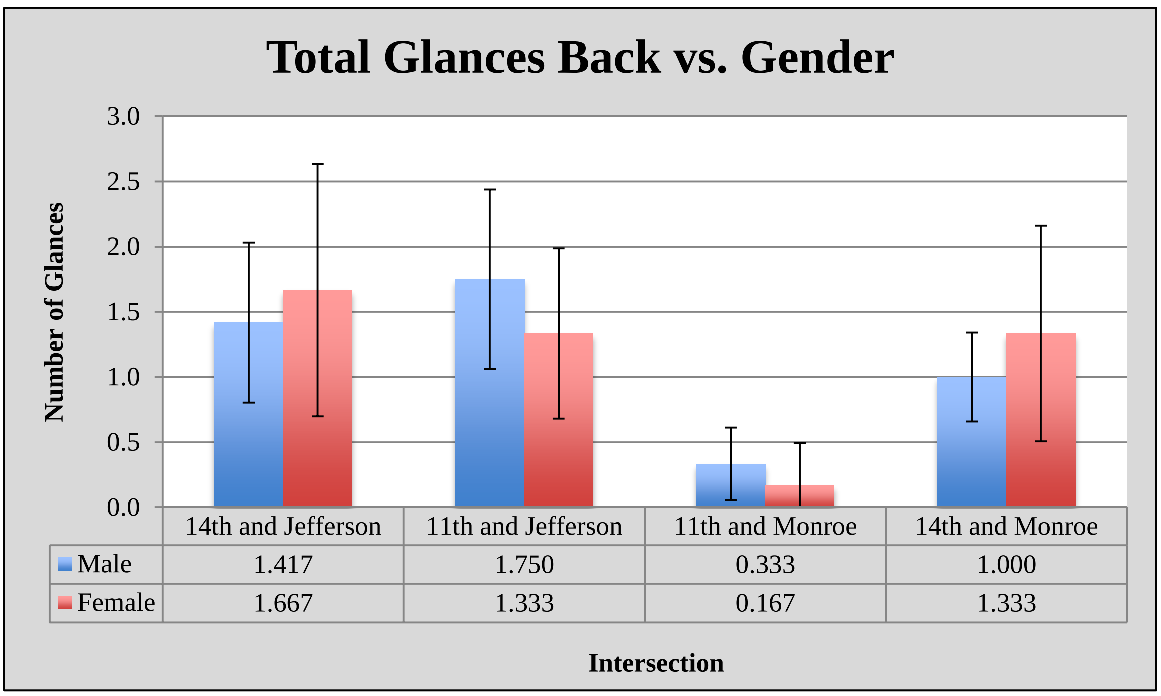

Figure 20: Total Glances Back vs. Gender with 95% CI

Based on the graphical information, females glanced back more at the signalized intersections while males glanced back more at unsignalized intersections. This suggests females exhibit more caution when approaching a signalized intersection due to the increased number of pedestrians and vehicle traffic. In order to statistically represent the total glances back compared with gender, a two-tail t-test was analyzed with unequal variance. These results can be found in Table 8.

Table 8: Analysis of Total Glances Back vs. Gender

Intersection	Comparison
	Male and Female
	P-Value
14th and Jefferson	0.679
11th and Jefferson	0.404
11th and Monroe	0.461
14th and Monroe	0.489

Similar to the findings regarding left and right glances, there are no statistically significant p-values. Regarding total glances back, the relatively low number of glances for males and females (all averages under two) makes it difficult to test any statistical differences. There were also only 12 males and six females involved within this research making it difficult to satisfy any statistical requirements. Due to the findings and p-values, there is not enough information to reject the null hypothesis that there is no difference in the visual search pattern of glancing back compared with males and females.

4.4 Time from Intersection of Glance Back

One of the most important and dangerous maneuvers a bicyclist performs is merging into the traffic lane to turn left. Before a bicyclist performs this maneuver, they glance back in order to visually address the surrounding traffic. The bicyclist must glance within a window that allows them to safely move into the lane before the intersection while still allowing motor vehicles to behave naturally. It can be assumed that the earlier one glances before approaching an intersection, the more cautious they are. This allows the bicyclist to have more time to perform the lane merge. The closer one gets to an intersection and the less time they have to merge can be contributed to experience in that the more comfortable a bicyclist is, the less time they need to perform this maneuver.

4.4.1 Time from Intersection of Glance Back vs. Intersections

The time from each intersection when the bicyclist glanced back is shown in Figure 21. These values were taken from all subjects who glanced back before merging into the left turn lane. Out of all 18 participants, 17 glanced back at the first intersection of 14th and Jefferson, 17 glanced back at 11th and Jefferson, and 15 glanced back at 14th and Monroe. This data will be used to test the null hypothesis regarding the visual search patterns and intersections of different levels of control.

H_O: There is no difference in the visual search patterns of bicyclists at intersections with different levels of control.

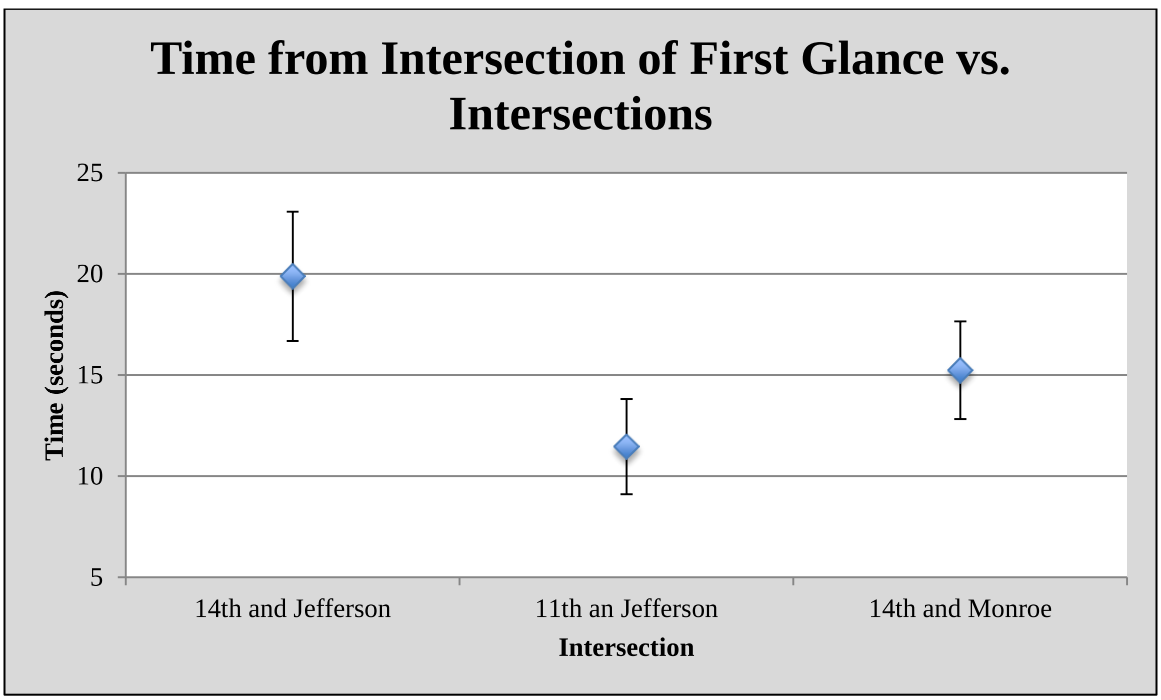

Figure 21: Time from Intersection of First Glance vs. Intersections with 95% CI

To determine whether or not the time of first glance was different between intersections, t-tests with two-tails and unequal variance with were conducted between each intersection. Comparisons were closely made between the signalized (14th and Jefferson and 14th and Monroe) and unsignalized (11th and Jefferson) intersections in order to see if the type of intersection has an effect on the time in which a bicyclist glances back. These results can be found in Table 10. Comparisons were also made regarding experience and gender between these intersections. These comparisons with experience and gender were used to test the differences between intersections, not the differences of experience or gender.

Table 9: First Glance vs. Intersections

Measures	**Intersection**		
	14th and Jefferson	11th and Jefferson	14th and Monroe
	Average time (s)		
All	19.882	11.461	15.228
Novice	18.823	10.586	15.354
Intermediate	23.712	14.791	16.145
Advanced	17.669	8.785	15.299
Male	18.851	10.398	14.121
Female	21.771	13.409	17.443

Table 10: Analysis of First Glance vs. Intersections

Measures	**Comparison**			
	ANOVA	14th and Jefferson with 11th and Jefferson	14th and Jefferson with 14th and Monroe	11th and Jefferson with 14th and Monroe
	P-Value			
All	**<0.001**	**<0.001**	**0.031**	**0.037**
Novice	0.104	0.069	0.403	0.117
Intermediate	**0.013**	**0.014**	**0.018**	0.614
Advanced	0.106	**0.024**	0.613	0.181
Male	**<0.001**	**<0.001**	**0.044**	0.076
Female	0.167	0.112	0.337	0.232

First, a comparison between intersections was made, regardless of experience or gender. This was used to determine if there are any differences in the time before approaching an intersection of when a bicyclist glances back. All three comparisons had significance differences. This was also validated using an ANOVA analysis. The biggest disparity is between 14th and Jefferson and 11th and Jefferson with a mean difference of over eight seconds. This is expected because one is a signalized intersection while the other is a unsignalized intersection. The difference in intersection design as well as vehicle lanes makes the intersections drastically different and thus the bicyclist behavior differs as well. This makes sense regarding the differences of signalized and unsignalized intersections, however, the difference in 14th and Jefferson and 14th and Monroe is unexpected. This is because both are signalized intersections and it would be assumed there would be no disparity between the two. This suggests that intersection design plays a key part in the visual search patterns of bicyclists, not just the type of intersection.

Second, a comparison was made between each intersection by classifying the subjects based on experience. These mean values were then compared with each intersection to see if there were any differences. The biggest difference occurs between 14th and Jefferson and 11th and Jefferson as expected. Intermediate and advanced bicyclists provided significant differences in visual search patterns between these two intersections while novice was just above the requirement of 0.05. Intermediate bicyclists saw a significant difference between 14th and Jefferson and 14th and Monroe. This finding is unusual because both are signalized intersections. Neither novice nor advanced subjects showed any significant differences between these intersections. There were no significant statistical differences between 11th and Jefferson and 14th and Monroe regarding experience. The ANOVA analysis provided a p-value below 0.05 for the intermediate experience, but not novice or advanced. This provides little understanding regarding the differences amongst intersections with regards to experience.

Finally, a comparison was made between each intersection based on gender. Males provided significant differences between 14th and Jefferson and 11th and Jefferson as well as between 14th and Jefferson and 14th and Monroe. There is a mean difference of over eight seconds with the first comparison and a difference of over four seconds for the second. The ANOVA analysis concluded males exhibit statistically significant differences regarding glances back between intersections while females did not.

It is difficult to conclusively tell whether or not the visual glance back differs between intersections based on this data. It can be concluded that the most significantly differing intersections were those of 14th and Jefferson and 11th and Jefferson. Out of the possible six comparisons, there were significant differences in four of the categories with the other two being close. The most unexpected differences occurred between 14th and Jefferson and 14th and Monroe, which are both signalized intersections. Out of the possible six categories, these intersections were different in three. Out of the total 18 categories, eight provided significant differences while all three of the p-values comparing intersections were significant. For the question of when does a bicyclist glance back while approaching the intersection, it can be concluded that it does reject the null hypothesis that there is a difference in the visual search patterns of bicyclists at intersections of different levels of control. This is because the three intersections were compared to each other based on the total average time, they all provided p-values less than 0.05, thus proving significant.

4.4.2 Time from Intersection of Glance Back vs. Experience

Figure 22 shows time form each intersection of the bicyclist's glance back compared with experience for the intersections of 14th and Jefferson, 11th and Jefferson, and 14th and Monroe respectively. During the first and second intersections, out of those who glanced back, six were novice, six were intermediate, and four were advanced. The last intersection of 14th and Monroe had only five novice, five intermediate, and four advanced subjects.

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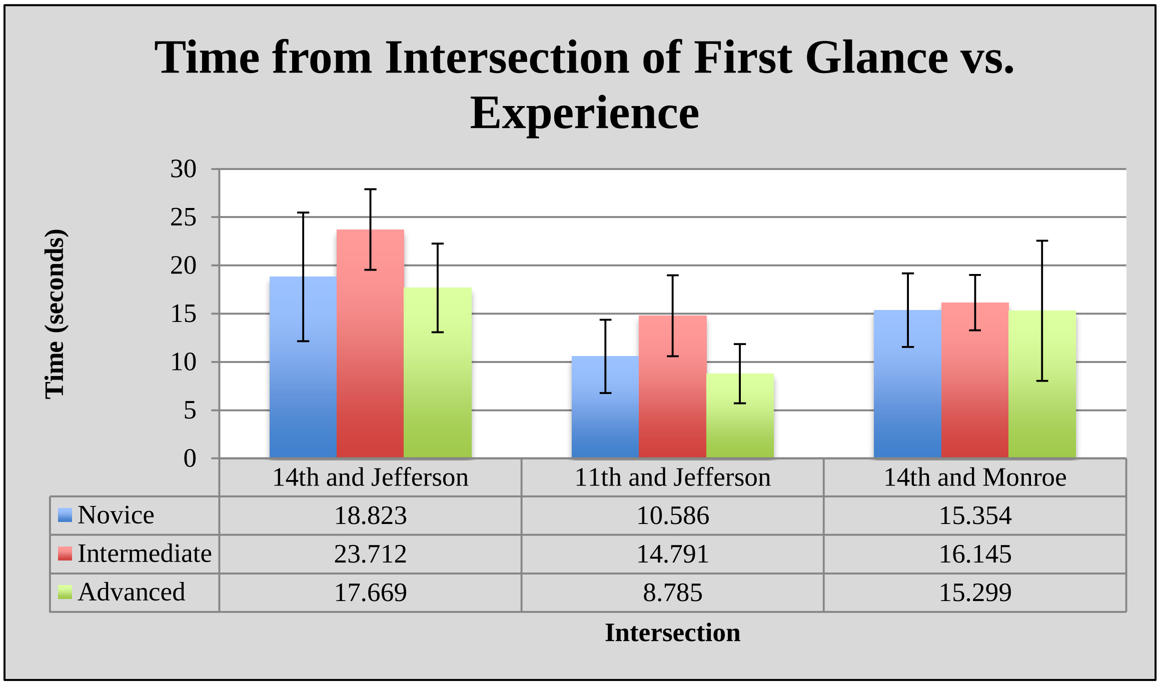


Figure 22: Time from Intersection of First Glance vs. Experience with 95% CI

To determine whether or not the time of first glance was different based on experience, t-tests with two-tails and unequal variance were conducted. These results were then used to validate or reject the null hypothesis listed below. Comparisons were made between each level of experience and at what intersection. These results can be found in Table 11.

H$_O$: *There is no difference in the visual search task and behavior of experienced and non-experienced bicyclists at intersections.*

Table 11: Analysis of First Glance vs. Experience

Intersection	Comparison			
	ANOVA	Novice and Intermediate	Novice and Advanced	Intermediate and Advanced
	P-Value			
14th and Jefferson	0.304	0.257	0.787	0.098
11th and Jefferson	0.140	0.176	0.490	0.053
14th and Monroe	0.959	0.754	0.990	0.843

Out of all statistical tests between experience and for each intersection, none proved statistically significant. There are huge disparities between the means, however no statistical differences. This can be contributed to the low number of subjects and data. Only four possible subjects selected advanced. This makes it difficult to have any definite statistical conclusions due to the low number of tests. Out of the nine possible statistical categories, none proved significant. An ANOVA analysis was analyzed in order to further test if there were any statically differences amongst experience. The ANOVA analysis, similar to the t-test analysis, provided no statistically significant p-values. Regarding the question of when does a bicyclist glance back while approaching the intersection, it can be concluded that it does not reject the null hypothesis that there is no difference in the visual search patterns of bicyclists based on experience.

4.4.3 Time from Intersection of Glance Back vs. Gender

Figure 23 shows a bar chart based on gender for the intersections of 14th and Jefferson, 11th and Jefferson, and 14th and Monroe respectively. There were 11 males and six females for the first two intersections, and 10 males and five females for the last intersection respectively.

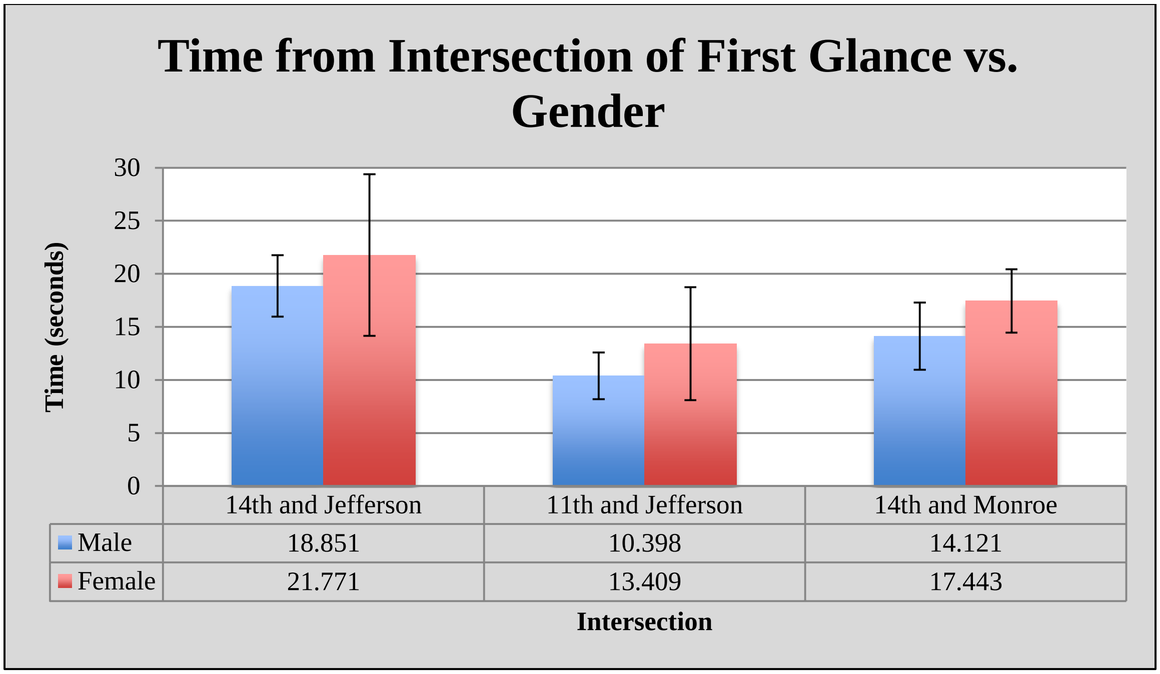


Figure 23: Time from Intersection of First Glance vs. Gender with 95% CI

To determine whether or not the time of first glance was different based on gender, t-tests with two-tails and unequal variance were analyzed. These results were then used to validate or reject the null hypothesis listed below. Comparisons were made between each gender and at what intersection. These results can be found in Table 12.

***H_O**: There is no difference in the visual search task and behavior of males and females at intersections.*

Table 12: Analysis of First Glance vs. Gender

Intersection	**Comparison**
	Male and Female
	P-Value
14th and Jefferson	0.410
11th and Jefferson	0.244
14th and Monroe	0.215

Similar to the tests regarding experience, there are no significant statistical differences between males and females. This can be largely contributed to the low number of data and subjects. The bar charts all show differences between males and females, however, the t-test does not. Based on the graphical representation, females give themselves more time before the intersection when they glance back, thus more caution. Based on the question of when does a bicyclist glance back while approaching the intersection, it can be determined that it does not reject the null hypothesis that there is no difference in the visual search patterns of bicyclists based on gender.

4.5 Time from Intersection of Lane Merge

Similar to the glance back, the lane merge is a crucial aspect of safety for bicyclists. Where and when a bicyclist merges lanes can drastically affect their safety with motor vehicles. If a bicyclist chooses to merge too quickly, they can affect the speed and nature of the motor vehicles around them. If they choose to merge too late, then they could possibly miss the merge all together. In relation to the glance back, the more time someone gives himself or herself to merge lanes, the more cautious they are as they allow more time to process the maneuver. Consequently, the less time someone gives himself or herself to merge, the more comfortable they are interacting with motor vehicles.

4.5.1 Time from Intersection of Lane Merge vs. Intersections

The mean values for the amount of time that a bicyclist gives himself or herself before reaching the intersection when they merge lanes can be found in Figure 24. Graphically, all three intersections drastically differ from one other in terms of time when they merged lanes. This can be attributed to the different intersection designs. The different intersection approaches and layouts require the bicyclists to alter their behavior when merging in order to safely switch lanes. This data will be used to test the null hypothesis regarding the visual search patterns of intersections of different levels of control.

H_O: There is no difference in the visual search patterns of bicyclists at intersections with different levels of control.

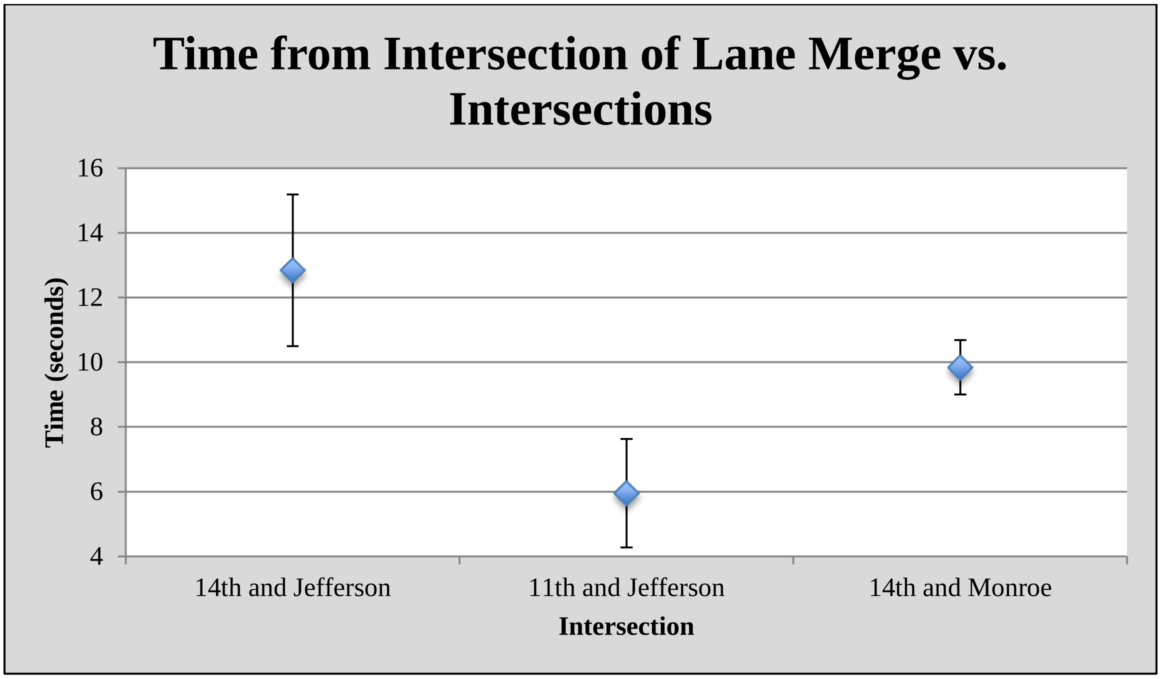


Figure 24: Time from Intersection of Lane Merge vs. Intersections with 95% CI

In order to statistically test the merge times for each intersection, two-tail t-tests with unequal variance were analyzed for each intersection and found within Table 14. This table also highlights experience and gender, however, the focus for this null hypothesis is concerned with the different intersections, and not how experience or gender influence behavior.

Table 13: Lane Merge vs. Intersections

Measures	Intersection		
	14th and Jefferson	11th and Jefferson	14th and Monroe
	Average time (s)		
All	12.845	5.954	9.842
Novice	14.716	6.186	10.729
Intermediate	12.314	6.406	9.278
Advanced	11.524	4.634	9.872
Male	11.360	6.006	9.263
Female	15.320	5.868	11.001

Table 14: Analysis of Lane Merge vs. Intersections

Measures	Comparison			
	ANOVA	14th and Jefferson with 11th and Jefferson	14th and Jefferson with 14th and Monroe	11th and Jefferson with 14th and Monroe
	P-Value			
All	**<0.001**	**<0.001**	**0.029**	**<0.001**
Novice	**0.042**	**0.039**	0.232	0.074
Intermediate	**<0.001**	**0.016**	0.126	0.055
Advanced	**0.004**	**0.024**	0.229	**0.040**
Male	**<0.001**	**<0.001**	**0.014**	**0.006**
Female	**0.021**	**0.025**	0.201	**0.041**

When comparing the intersections of 14th and Jefferson with 11th and Jefferson, all p-values were considered significant. This is understandable because 14th and Jefferson is a signalized intersection whereas 11th and Jefferson is a unsignalized intersection. The first intersection has a greater amount of vehicles and pedestrians increasing the likelihood of a crash. As a result, bicyclists must merge sooner in order to safely avoid the risk of a crash or accident. When 11th and Jefferson was compared with 14th and Monroe, this too proved statistically significant in four out of six categories. Similar to the first comparison, this compares a signalized and unsignalized intersection.

The main category labeled all is the most important regarding this null hypothesis because it is comparing the average times of all participants through each intersection. ANOVA was also used to test the differences between intersections. P-values below 0.05 were found in all categories. This further validates the differences between intersections with regards to time of the lane merge. Because all three intersections comparisons within the all category and ANOVA analysis were significant, it can be concluded that there is enough information to reject the null hypothesis stating there is no different in the visual search patterns of bicyclists at different intersections.

4.5.2 Time from Intersection of Lane Merge vs. Experience

Bar charts were made for each intersection and grouped by experience as shown in Figure 25**.** Graphically, there seems to be little consistency regarding experience and the time when the bicyclist merges lanes. Novice bicyclists gave themselves the most amount of time while merging at 14^{th} and Jefferson and 14^{th} and Monroe whereas intermediate bicyclists gave themselves the most amount of time at 11^{th} and Jefferson. Advanced bicyclists gave themselves the least amount of time at the intersections of 14^{th} and Jefferson and 11^{th} and Jefferson while intermediate bicyclists gave themselves the least amount of time at the intersection of 14^{th} and Monroe.

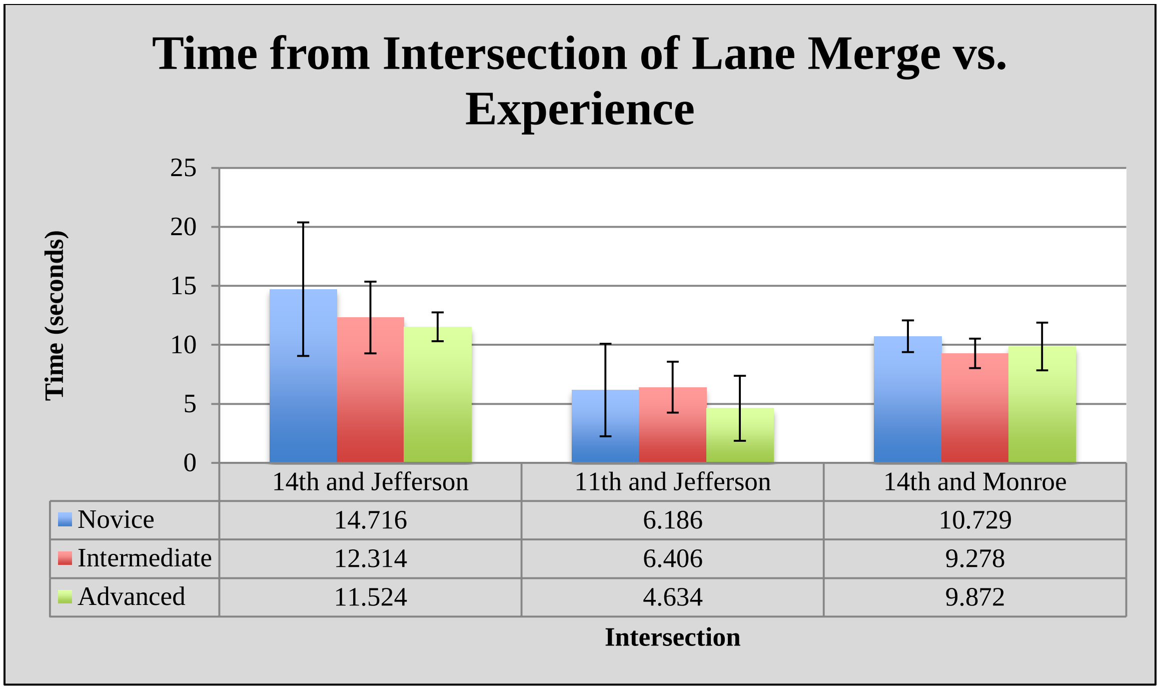


Figure 25: Time from Intersection of Lane Merge vs. Experience with 95% CI

In order to test the null hypothesis listed below, a t-test with two-tails and unequal variance was analyzed for each experience and intersection, as seen in Table 15.

H_O: *There is no difference in the visual search task and behavior of experienced and non-experienced bicyclists at intersections.*

Table 15: Analysis of Lane Merge vs. Experience

Intersection	**Comparison**			
	ANOVA	Novice and Intermediate	Novice and Advanced	Intermediate and Advanced
	P-Value			
14th and Jefferson	0.582	0.486	0.326	0.655
11th and Jefferson	0.789	0.926	0.546	0.372
14th and Monroe	0.409	0.158	0.516	0.645

Statistically, there are no significant p-values. This is not unusual for this data set because the average times when the bicyclists merged are fairly consistent with each other. The largest margin of times was in the intersection of 14th and Jefferson between novice and intermediate with a difference of 2.4 seconds. Despite a large difference, the t-test resulted in a p-value of only 0.486, which was too high to prove statistically significant. Along with the t-test analysis, an ANOVA analysis was conducted to further validate or reject the hypothesis. Similar to the t-test analysis, the ANOVA analysis provided no statistically significant p-values. With the statistical information provided above, there is not enough evidence to reject the null hypothesis that experience does not influence the visual search patterns of bicyclists.

4.5.3 Time from Intersection of Lane Merge vs. Gender

Figure 26 shows a bar chart based on gender for the intersections of 14th and Jefferson, 11th and Jefferson, and 14th and Monroe respectively. There were 10 males and six females for the first two intersections, and 10 males and five females for the last intersection respectively. This information will be used to test the null hypothesis listed below.

$\boldsymbol{H_O}$*: There is no difference in the visual search task and behavior of males and females at intersections.*

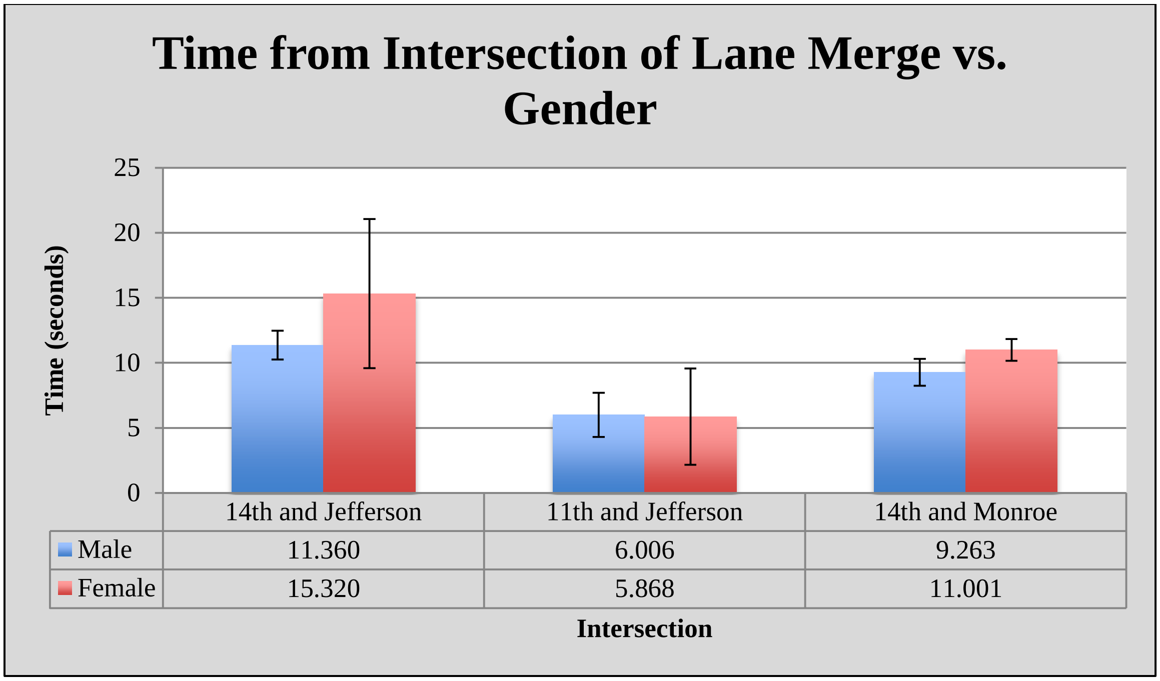


Figure 26: Time from Intersection of Lane Merge vs. Gender with 95% CI

Graphically, it seems consistent that at signalized intersections (14th and Jefferson and 14th and Monroe) females give themselves significantly more time while approaching the intersection when they merge lanes. At the intersection of 14th and Jefferson, there is a mean difference of nearly four seconds and at the intersection of 14th and Jefferson there is a difference of just less than two seconds. To test whether or not these values are statistically different, t-tests with two-tails and unequal variance were analyzed comparing males and females at each intersection. These results can be found in Table 16 as shown below.

Table 16: Analysis of Lane Merge vs. Gender

Intersection	**Comparison**
	Male and Female
	P-Value
14th and Jefferson	0.237
11th and Jefferson	0.949
14th and Monroe	**0.024**

There seems to be no statistical difference of males and females at the first two intersections, however, at the intersection of 14^{th} and Monroe there is a p-value lower than 0.05, thus proving significant. Despite the low number of participants at this intersection (10 males and five females), the data was close enough to provide statistical differences.

Even though the intersection of 14^{th} and Monroe provided statistical differences, the other two intersections did not. This makes it difficult to reject the null hypothesis. As a result, the null hypothesis that gender influences glance patterns cannot be rejected and is therefore validated.

4.6 Time Between Glance and Lane Merge

As previously stated, merging into the left turn lane provides a difficult and challenging maneuver that if not done correctly, can drastically increase the likelihood of a BMV crash. After the bicyclist glances behind them, they have the choice of whether or not it is safe to merge into the lane. This maneuver takes only a few seconds, but determines if the bicyclist can use the left turn lane or not.

Instead of using the first glance back, the last glance was used to in order to best analyze the data. This discounts the unknown variable of whether or not a car was in the vehicle lane. If a subject glances behind them and sees a car, they will most likely wait until the car passes by before they glance behind them again. After doing so, they will merge into the left turn lane.

4.6.1 Time Between Glance and Lane Merge vs. Intersections

It can be assumed that the less time it takes someone to glance back and merge lanes, the more experienced and comfortable they are. This can be said because once a bicyclist sees an opening to merge, the sooner they merge, and the safer they are. The longer delay can result in a motor vehicle reaching the bicyclists. The mean values for the amount of time between the glance back and merge can be found in Figure 27. Graphically, there seems to be little to no difference associated with the three intersections presented. This information will be used to test the null hypothesis regarding intersection types and visual search patterns.

H_O: *There is no difference in the visual search patterns of bicyclists at intersections with different levels of control.*

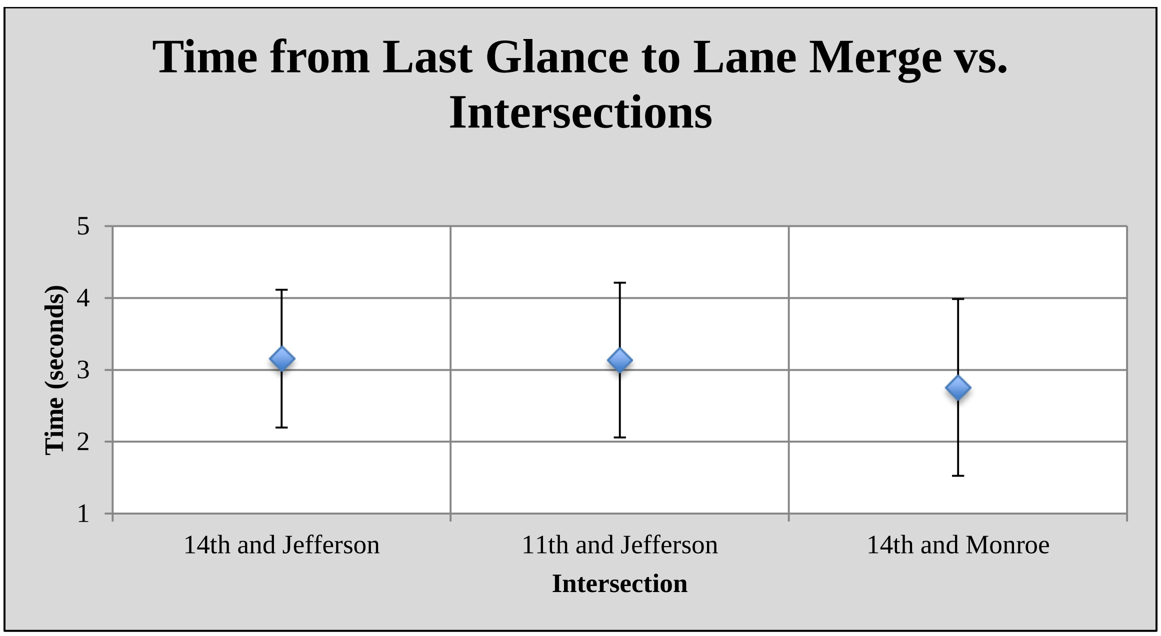


Figure 27: Time from Last Glance to Lane Merge vs. Intersections with 95% CI

By examining the graph above, there seem to be little differences between intersections. In order to test if differences exist, a t-test with two-tails and unequal variance was conducted with each intersection. These results can be found in Table 18**.** The measures compared each intersection with all subjects, grouped by experience, and grouped by gender.

Table 17: Last Glance to Lane Merge vs. Intersections

Measures	Intersection		
	14th and Jefferson	11th and Jefferson	14th and Monroe
	Average time (s)		
All	3.158	3.136	2.755
Novice	3.564	3.029	4.624
Intermediate	3.389	3.998	1.522
Advanced	2.354	2.136	2.245
Male	3.144	2.692	2.350
Female	3.184	3.876	3.566

Table 18: Analysis of Last Glance to Lane Merge vs. Intersections

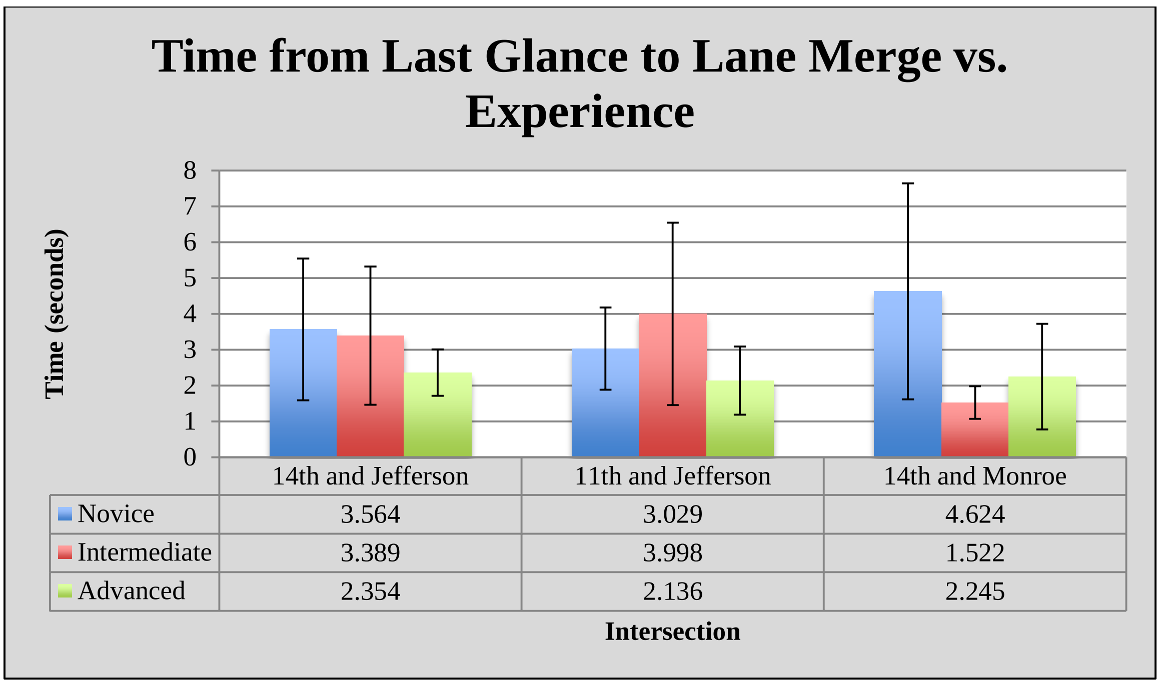
Measures	Comparison			
	ANOVA	14th and Jefferson with 11th and Jefferson	14th and Jefferson with 14th and Monroe	11th and Jefferson with 14th and Monroe
	P-Value			
All	0.850	0.977	0.617	0.651
Novice	0.583	0.659	0.582	0.376
Intermediate	0.248	0.717	0.118	0.116
Advanced	0.966	0.730	0.900	0.908
Male	0.656	0.644	0.335	0.688
Female	0.904	0.563	0.846	0.877

As the results show, there were no statistically significant comparisons regarding time between the last glance and lane merge. ANOVA was analyzed as well and provided the same result of no statistical differences. This can be attributed to the low amount of time required from the glance to merge. The largest average is 3.158 seconds while the lowest average is 2.755 for all subjects. This is less than 0.5 seconds difference and thus makes it difficult to provide any statistical differences. As a result, the null hypothesis stands and is validated.

4.6.2 Time Between Glance and Lane Merge vs. Experience

When measuring the time between the last glance and lane merge, subjects were grouped by experience and intersection with the results shown in Figure 28**.** Upon first examination, there seems to be little consistency regarding the amount of time between the glance and merge. Novice bicyclists took the longest at 14th and Jefferson and 14th and Monroe while intermediate bicyclists took the longest at 11th and Jefferson. In terms of the quickest times, advanced bicyclists took the least amount of time at 14th and Jefferson and 11th and Jefferson while intermediate took the least amount of time at 14th and Monroe. In terms of subjects grouped by experience, there were six novice, six intermediate, and four advanced at 14th and Jefferson, six novice, six intermediate, and three advanced at 11th and Jefferson, and five novice, five intermediate, and four advanced at 14th and Monroe. This data set was used to test the null hypothesis regarding experience and visual search patterns.

> $\boldsymbol{H_O}$*: There is no difference in the visual search task and behavior of experienced and non-experienced bicyclists at intersections.*



	14th and Jefferson	11th and Jefferson	14th and Monroe
Novice	3.564	3.029	4.624
Intermediate	3.389	3.998	1.522
Advanced	2.354	2.136	2.245

Figure 28: Time from Last Glance to Lane Merge vs. Experience with 95% CI

Graphically, it is difficult to notice any huge differences or consistencies. T-tests with two-tails and unequal variance were analyzed for each intersection based on experience with the results found in Table 19.

Table 19: Analysis of Last Glance to Lane Merge vs. Experience

Measure	**Comparison**			
	ANOVA	Novice and Intermediate	Novice and Advanced	Intermediate and Advanced
	P-Values			
14th and Jefferson	0.670	0.903	0.298	0.356
11th and Jefferson	0.512	0.519	0.282	0.227
14th and Monroe	0.119	0.114	0.216	0.415

Examining the table above reveals that none of the experience comparisons yielded statistically significant results. This was also true for the ANOVA analysis. There are two factors that can be assumed responsible for no statistical results. The first is the relatively small number of participants within each experience group and the second is the low amount of time being measured. As a result, there is not enough information to reject the null hypothesis regarding experience and visual search patterns.

4.6.3 Time Between Glance and Lane Merge vs. Gender

The last test performed compared gender in relation to the amount of time between the last glance and lane merge. These results are listed for each intersection and can be found in Figure 29. All three intersections reveal that females take slightly more time to perform the maneuver. These results will be used to test the null hypothesis regarding gender and visual search patterns.

H_O*: There is no difference in the visual search task and behavior of males and females at intersections.*

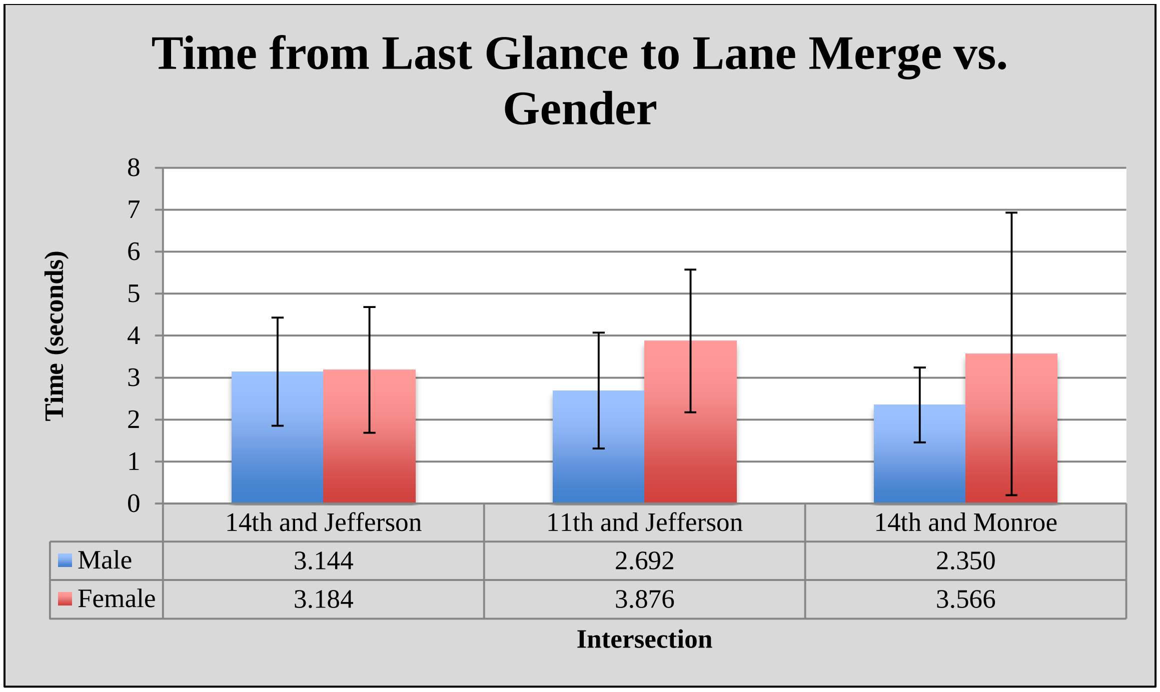


Figure 29: Time from Last Glance to Lane Merge vs. Gender with 95% CI

To test whether or not any statistical differences between males and females exist, t-tests with two-tails and unequal variance were performed and shown in Table 20.

Table 20: Analysis of Last Glance to Lane Merge vs. Gender

Intersection	Comparison
	Male and Female
	P-Value
14th and Jefferson	0.969
11th and Jefferson	0.311
14th and Monroe	0.527

As shown above, none of the intersections when comparing males and females provided enough statistical difference to prove significant. As stated in previous sections, the low number of subjects and low amount of time measured makes it difficult for find any statistical differences. In conclusion, there is not enough information to reject the null hypothesis about gender and visual search patterns.

5 CONCLUSION

To recap, the following hypotheses were tested within this experiment:

1. ***H_O**: There is no difference in the visual search patterns of bicyclists at intersections of different levels of control.*
2. ***H_O**: There is no difference in the visual search task and behavior of experienced and non-experienced bicyclists at intersections.*
3. ***H_O**: There is no difference in the visual search task and behavior of males and females at intersections.*

The following five questions were tested as the dependent variables and analyzed for each hypothesis.

1. How many times does the subject look left and right through an intersection?
2. How many total times does the subject glance back?
3. How much time before approaching the intersection does the subject have when they glance back?
4. How much time before approaching the intersection does the subject have when they merge lanes?
5. How much time elapses between the glance back and the lane merge?

Within these questions, comparisons were made between each intersection as well as comparisons between experience and gender. This was then used to validate or reject the listed null hypotheses. This allowed for each hypothesis to be tested five times. Questions 3,4, and 5 were split among the intersections of 14th and Jefferson, 11th and

Jefferson, and 14th and Monroe. 11th and Monroe did not provide enough data to be considered with the other intersections.

Table 21 below summarizes the results from each question and each hypothesis. Overall, the null hypothesis regarding experience and gender proved to be true for all questions. This can be contributed to the low number of subjects choosing each experience and gender. The null hypothesis regarding intersection designs on the visual search patterns was rejected in four out of five questions. As a result, the following null hypothesis is the only hypothesis rejected within this research. As a result, it can be concluded that bicyclists exhibit different visual search patterns between intersections of different levels of control.

$\boldsymbol{H_O}$: *There is no difference in the visual search patterns of bicyclists at intersections of different levels of control.*

Table 21: Summary of Questions vs. Null Hypotheses

Questions	Null Hypotheses		
	Intersections	Experience	Gender
Left and Right	Reject	Validate	Validate
Total Glances Back	Reject	Validate	Validate
Time of Glance Back	Reject	Validate	Validate
Time of Merge	Reject	Validate	Validate
Time between Glance Back and Merge	Validate	Validate	Validate

The following sections are organized by question and each summarizes the key findings within that question.

5.1 Conclusion: Left and Right Glances

The results of this question can be found in Section 4.2. Below are some key outcomes from this Section.

- Subjects looked left an average of 0.5 times more in all four intersections.
- Statistically significant differences (p-value < 0.05) supported the observation that bicyclists look left more than right at the intersection of 11th and Jefferson.

These results lead to the conclusion that subjects look left more at two-way stop intersections when the bicyclist is on the minor roadway turning onto the major roadway.

- Statistically significant differences (p-value <0.05) regarding left and right glances were found when intersections were compared with the intersection of 11th and Monroe.

This suggests that bicyclists glance left and right more often when waiting at a stop sign to turn left when compared with other intersections where the bicyclist has the right of way.

- There were no statistically significant differences associated with left and right glances when compared with experience and gender.

5.2 Conclusion: Total Number of Glances

The results of this question can be found in Section 4.3. Below are some key outcomes from this Section.

- Bicyclists glance back significantly less when on a roadway with no bike lanes and parking on both sides. All other intersections when compared with 11th and

Monroe provided statistically significant differences associated with the number of glances back.

This suggests that bicyclist’s exhibit more comfort regarding rear crashes when on a roadway with no bike lanes and parking on both sides. The reduction in road width limits other vehicles ability to pass the bicyclist. Therefore, when the bicyclist assumes the role as a vehicle, they are less likely to glance back because they do not need to perform a lane merge due to the fact they are already in the travel lane.

- There were no statistically significant differences associated with total glances back when compared with experience and gender.

5.3 Conclusion: Time from Intersection of Glance Back

The results of this question can be found in Section 4.4. Below are some key outcomes from this Section.

- Bicyclists provide more time before approaching the intersection while glancing back at signalized intersections. There were statistically significant differences when the signalized intersection of 14th and Jefferson was compared with the unsignalized intersection of 11th and Jefferson regarding time of glance back.

This suggests that bicyclists are more aware of the increase in motor vehicles and pedestrian traffic when approaching signalized intersections. As a result, they are more likely to glance back at an earlier time before approaching the intersection in order to provide more than enough time to merge lanes.

- Graphically, intermediate bicyclists gave themselves the most amount of time when glancing back at all three intersections. Statistically, there were no significant p-values.

Although there is not enough statistical reasoning to compare experience and time of glance back, preliminary data suggests that intermediate bicyclists give themselves more time to glance back. Novice bicyclists are unaware of all the dangers associated with riding a bicycle in the bike lane and thus are not as cautious while riding whereas advanced bicyclists are more comfortable acting as a vehicle. This suggests that a bicyclist will exhibit more caution as they begin to interact with vehicles more, but after acquiring enough experience, they will become less cautious. It is recommended to re-test this with a larger data set.

- Graphically, females gave themselves more time before approaching the intersection when they glanced back. Statistically, there were no significant p-values.

This suggests that females exhibit more caution while performing a left turn maneuver. This was the case in all three intersections tested. Males are considered more risky while bicycling and thus will give themselves less time before approaching the intersection when they glance back. It is recommended to provide a larger data set to statistically prove this theory.

5.4 Conclusion: Time from Intersection of Lane Merge

The results of this question can be found in Section 4.4. Below are some key outcomes from this Section.

- Bicyclists provide more time before approaching the intersection when merging at signalized intersections. There were statistically significant differences when all three intersections were compared.

This suggests that bicyclists alter the time and place of merging based on the design and demands of the intersection. Since signalized intersections typically have a heavier volume of vehicles and pedestrians, bicyclists give themselves more time before approaching the intersection when they choose to merge into the left turn lane. When the signalized intersections of 14th and Jefferson and 14th and Monroe were compared with the unsignalized intersection of 11th and Jefferson, they provided sufficient statistical evidence suggesting differences. As a result, bicyclists are more cautious when approaching signalized intersections when choosing to turn left.

- Graphically, there is little to no consistency or differences regarding experience and when the bicyclist chooses to merge into the left turn lane.

- Females gave themselves significantly more time while at signalized intersections when compared with males. The intersection of 14th and Monroe provided statistical evidence (p-value <0.05) suggesting the difference.

Based on the data, females gave themselves significantly more time while merging before the intersection, specifically at the signalized intersection of 14th and Monroe. This suggests that females are more cautious when choosing to merge lanes at signalized intersections.

5.5 Conclusion: Time Between Glance and Lane Merge

The results of this question can be found in Section 4.6. Below are some key outcomes from this Section.

- Statistically, there is little to no evidence of significant comparisons between intersections, experience, or gender

It is difficult to tell if there are any consistencies with the data provided. Further tests with more intersections are recommended.

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APPENDICES

Appendix A: Street Views

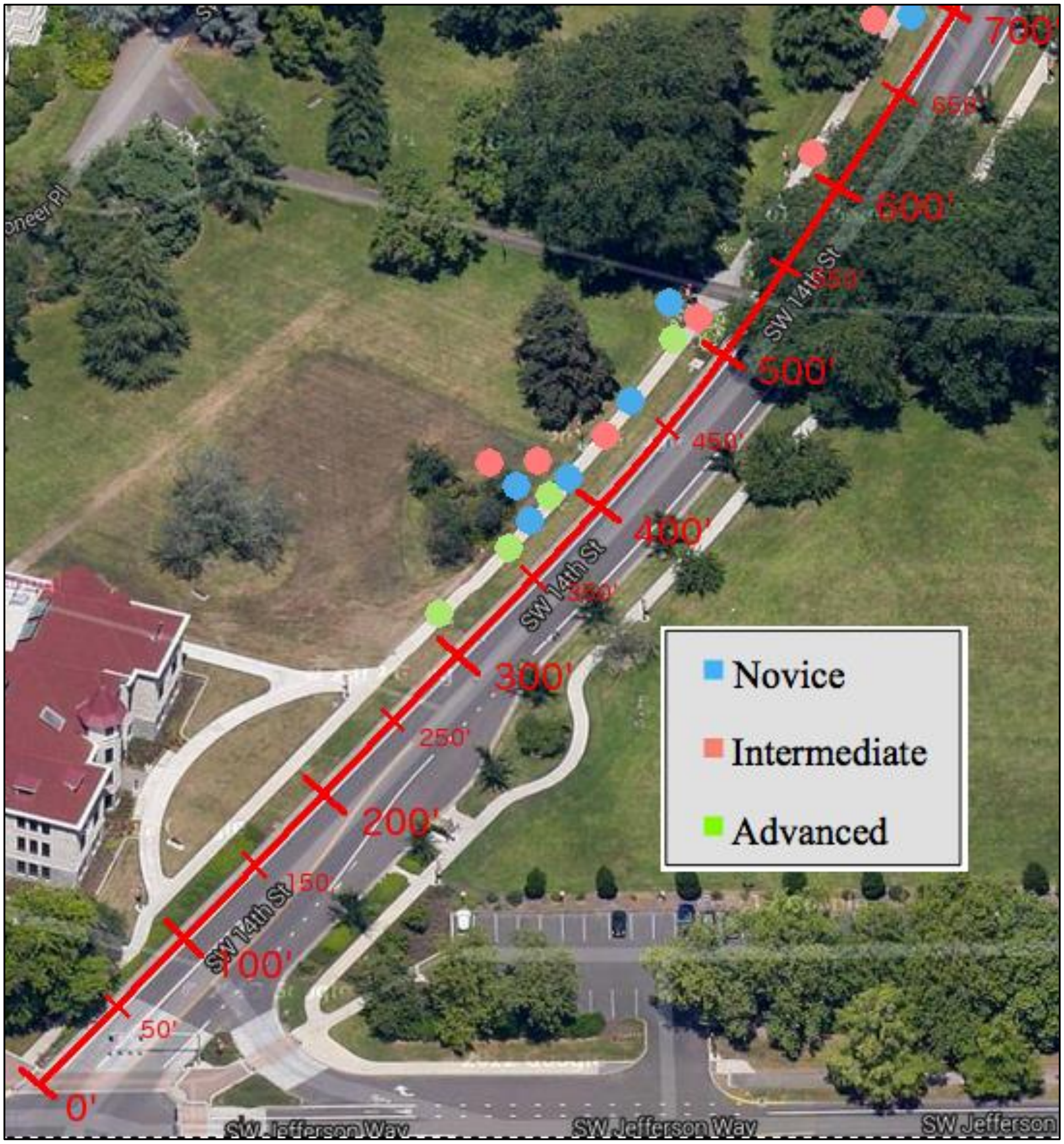

Figure A1: 14th and Jefferson - First Glance vs. Experience

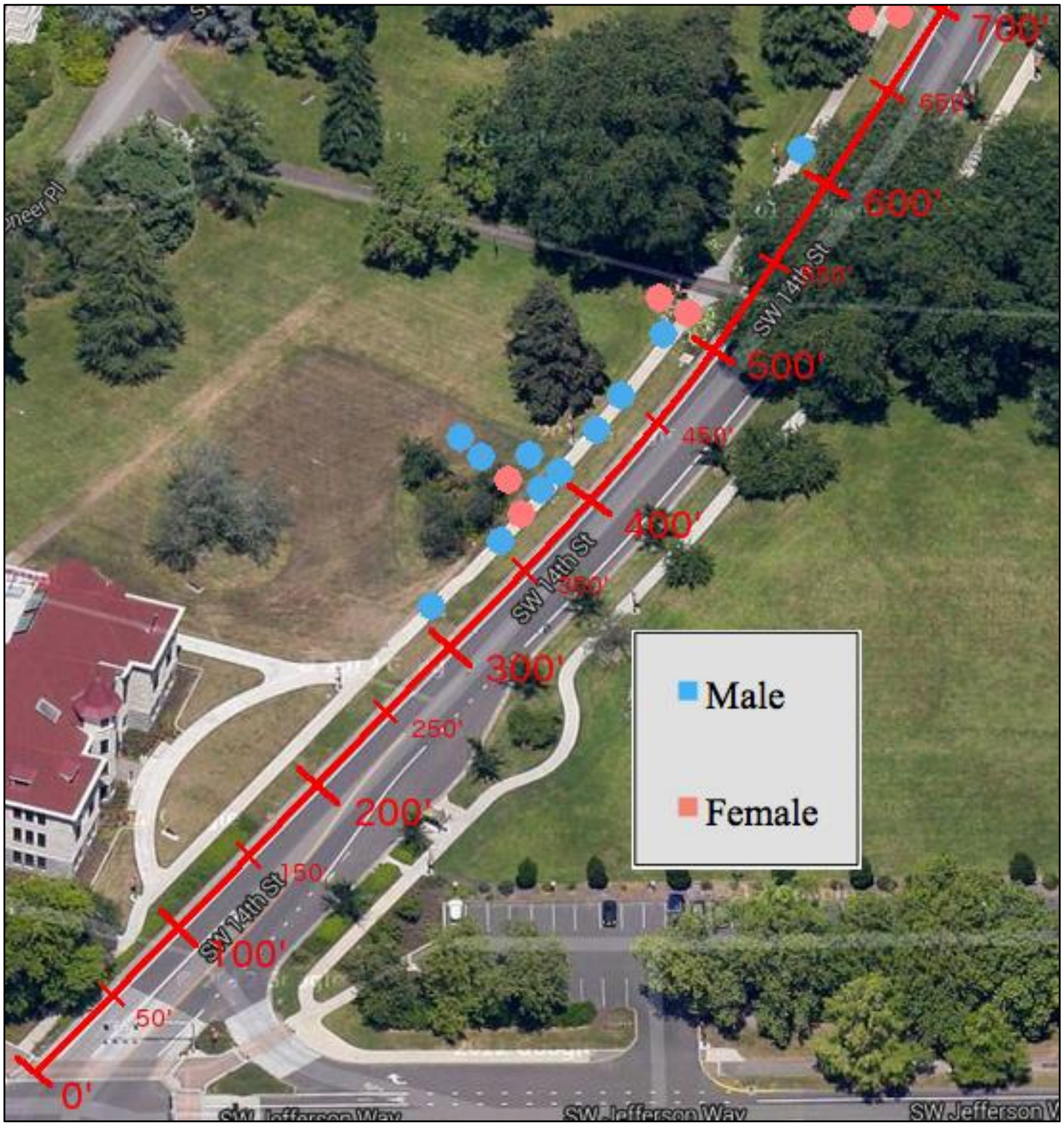

Figure A2: 14th and Jefferson - First Glance vs. Gender

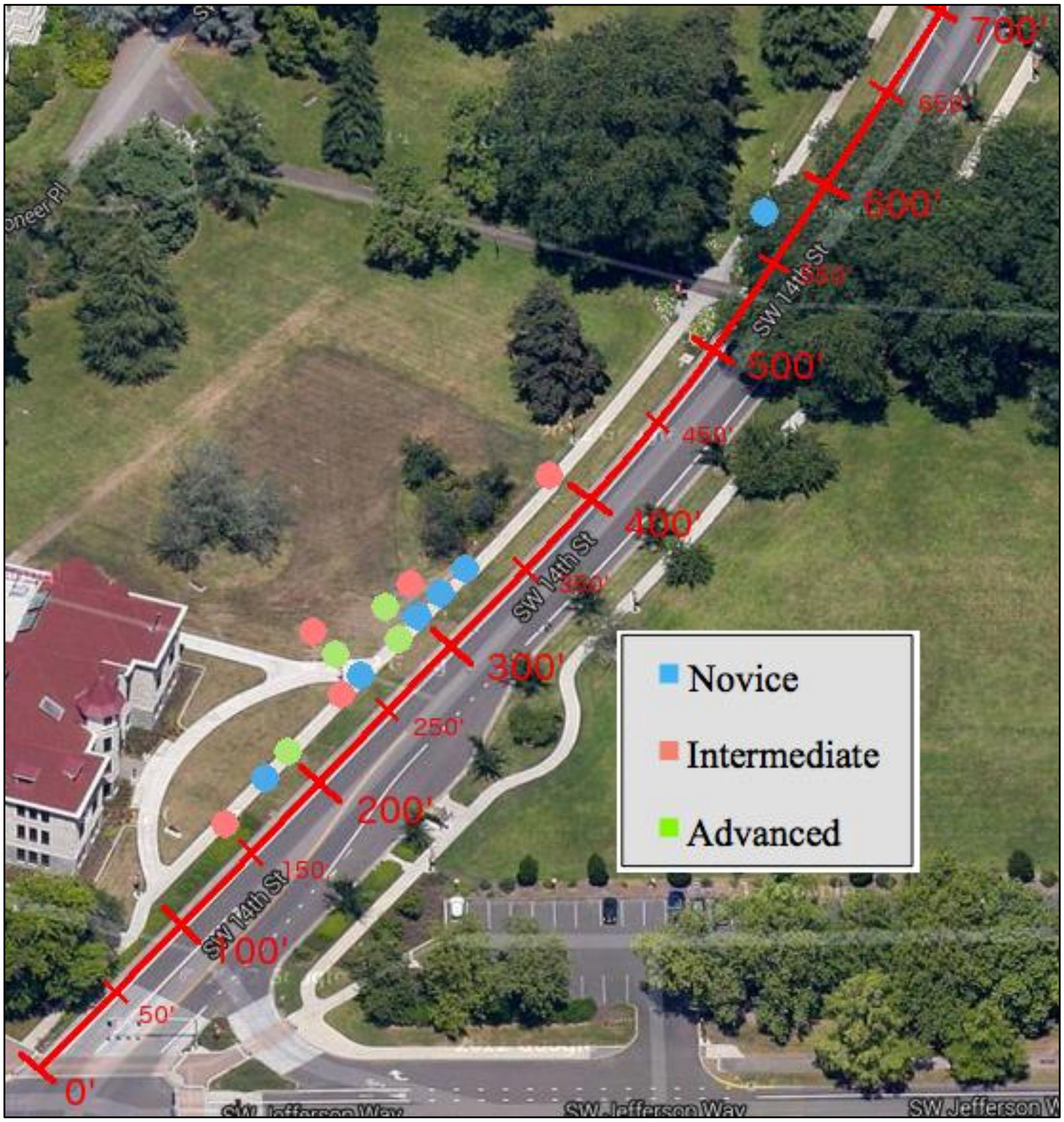

Figure A3: 14th and Jefferson - Lane Merge vs. Experience

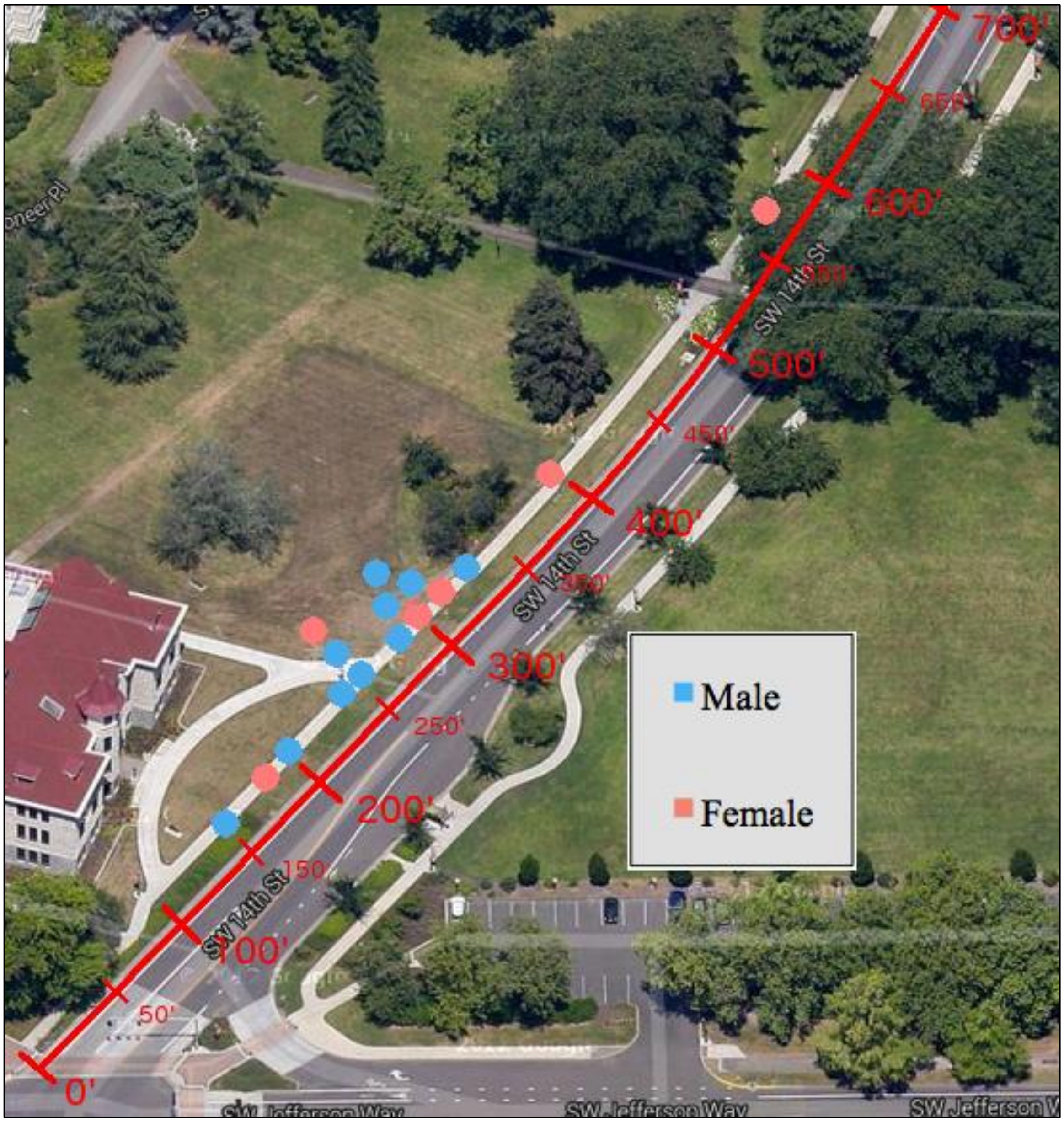

Figure A4: 14th and Jefferson - Lane Merge vs. Gender

Figure A5: 11th and Jefferson - First Glance vs. Experience

Figure A6: 11th and Jefferson - First Glance vs. Gender

Figure A7: 11th and Jefferson - Lane Merge vs. Experience

Figure A8: 11th and Jefferson - Lane Merge vs. Gender

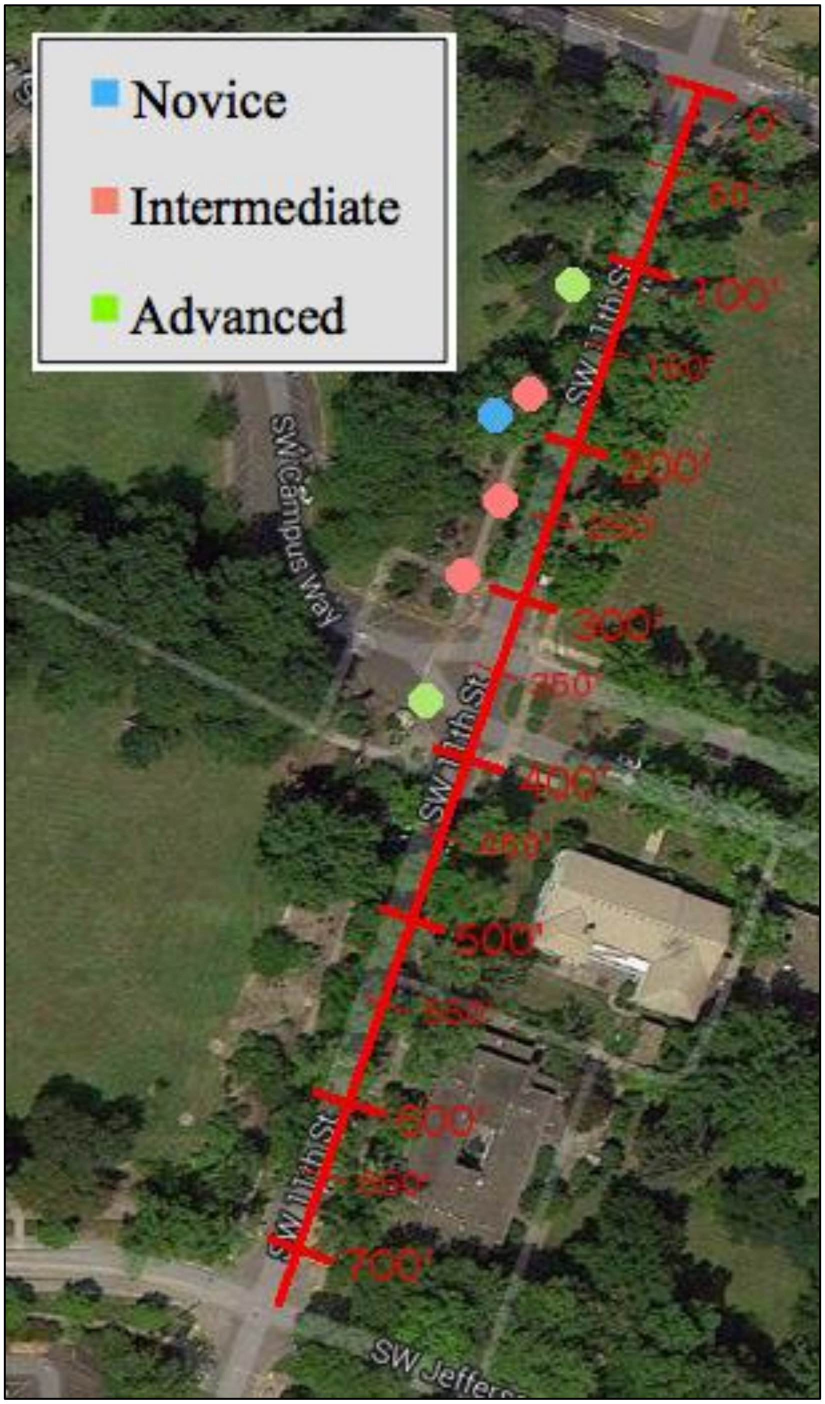

Figure A9: 11th and Monroe - First Glance vs. Experience

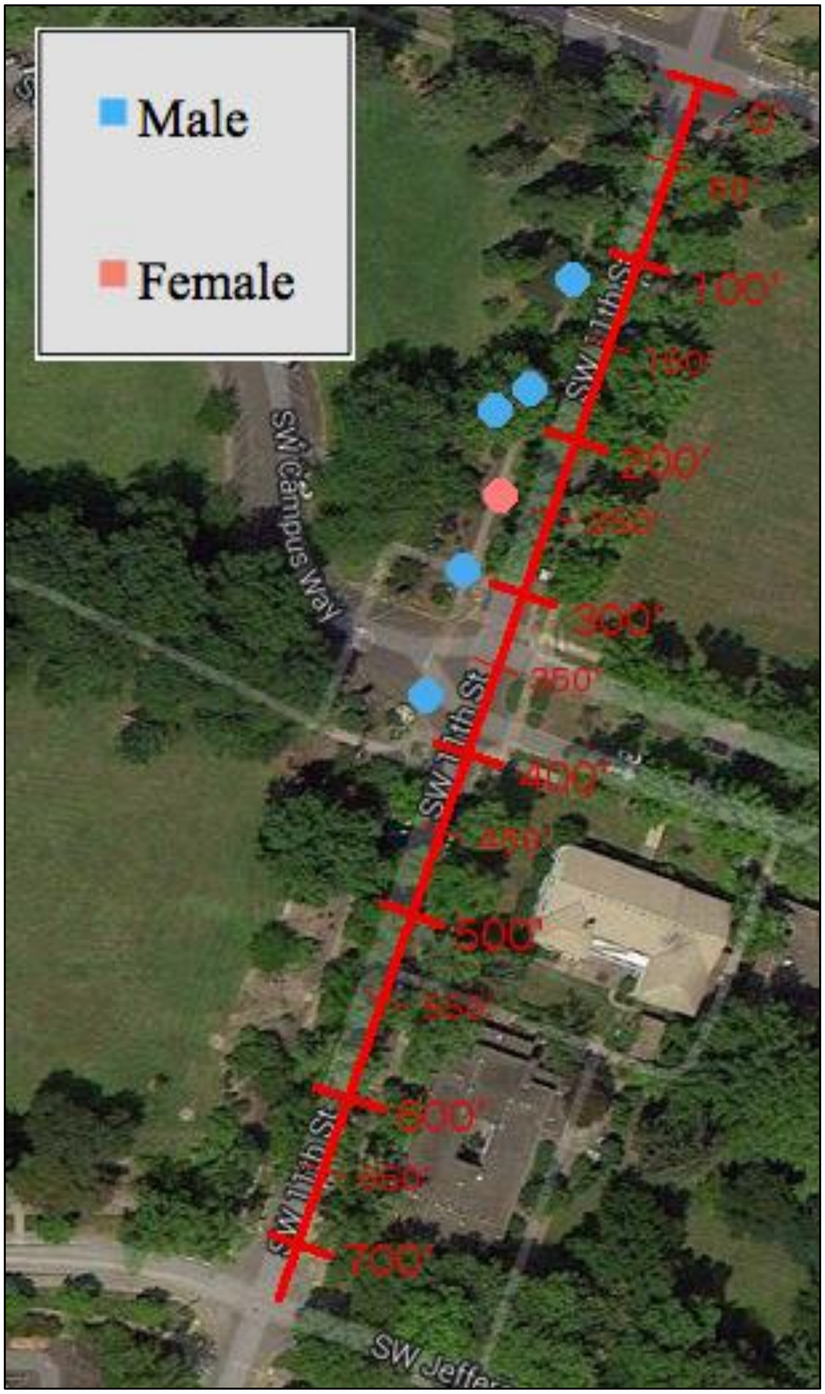

Figure A10: 11th and Monroe - First Glance vs. Gender

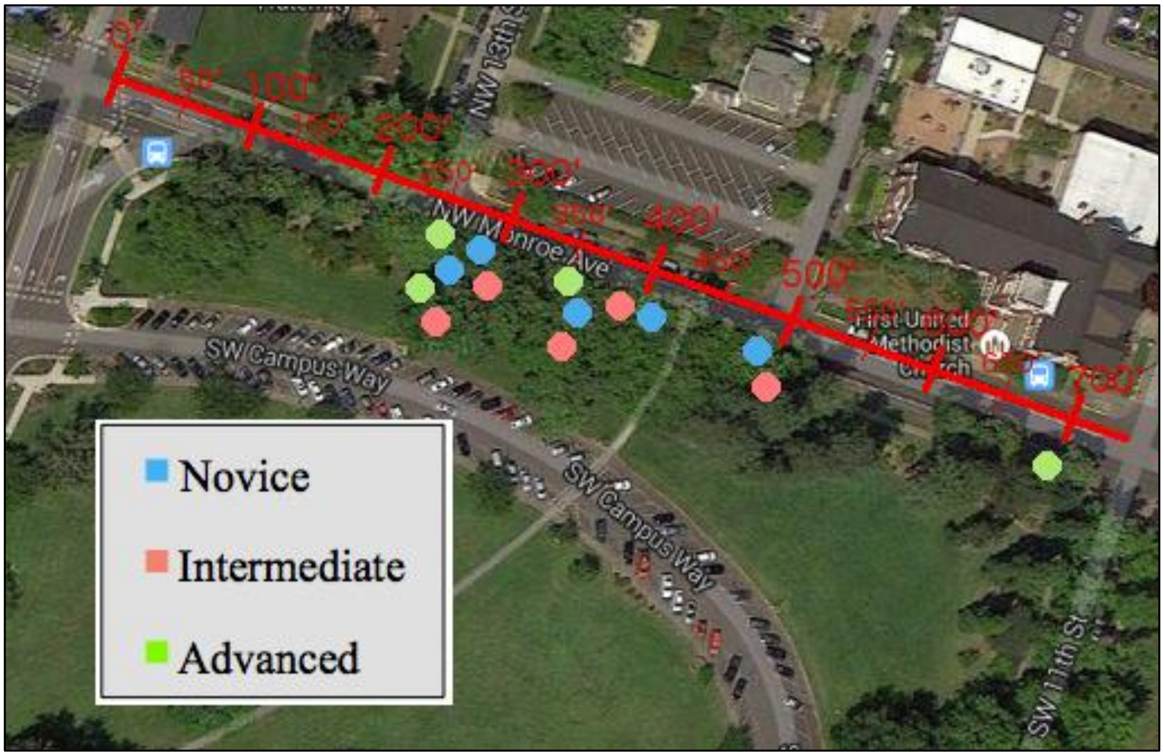

Figure A11: 14th and Monroe - First Glance vs. Experience

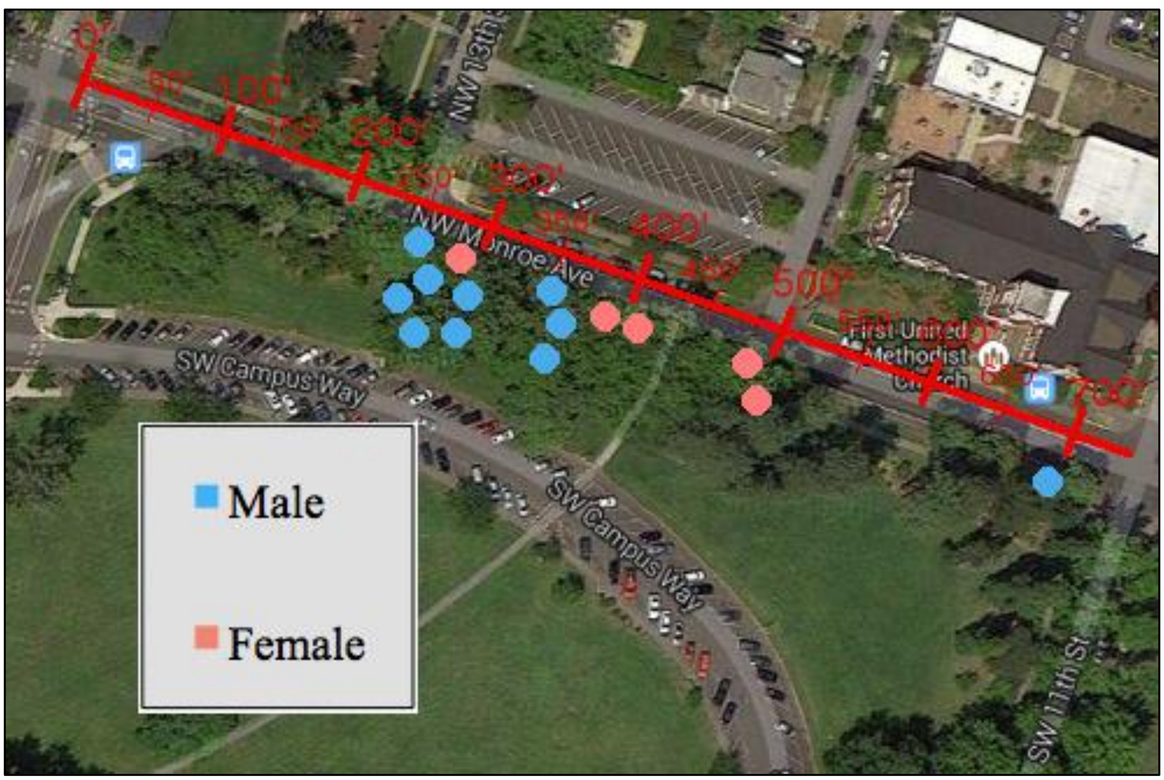

Figure A12: 14th and Monroe - First Glance vs. Gender

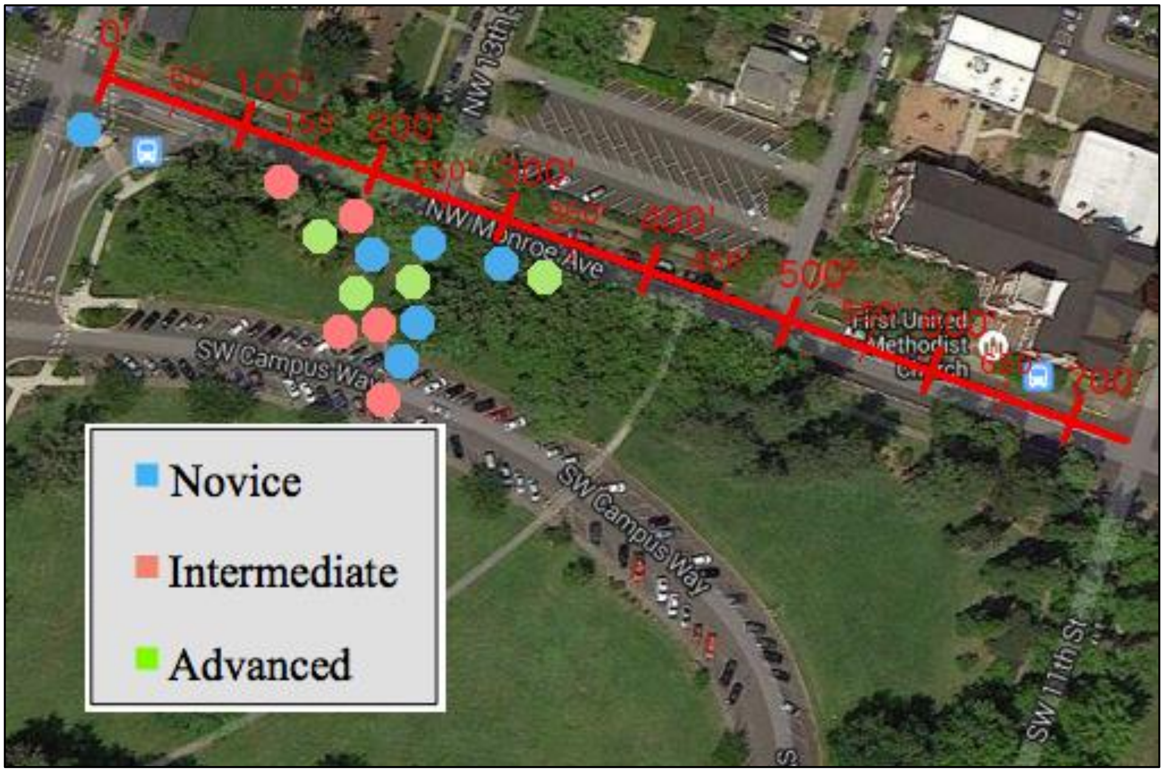

Figure A13: 14th and Monroe - Lane Merge vs. Experience

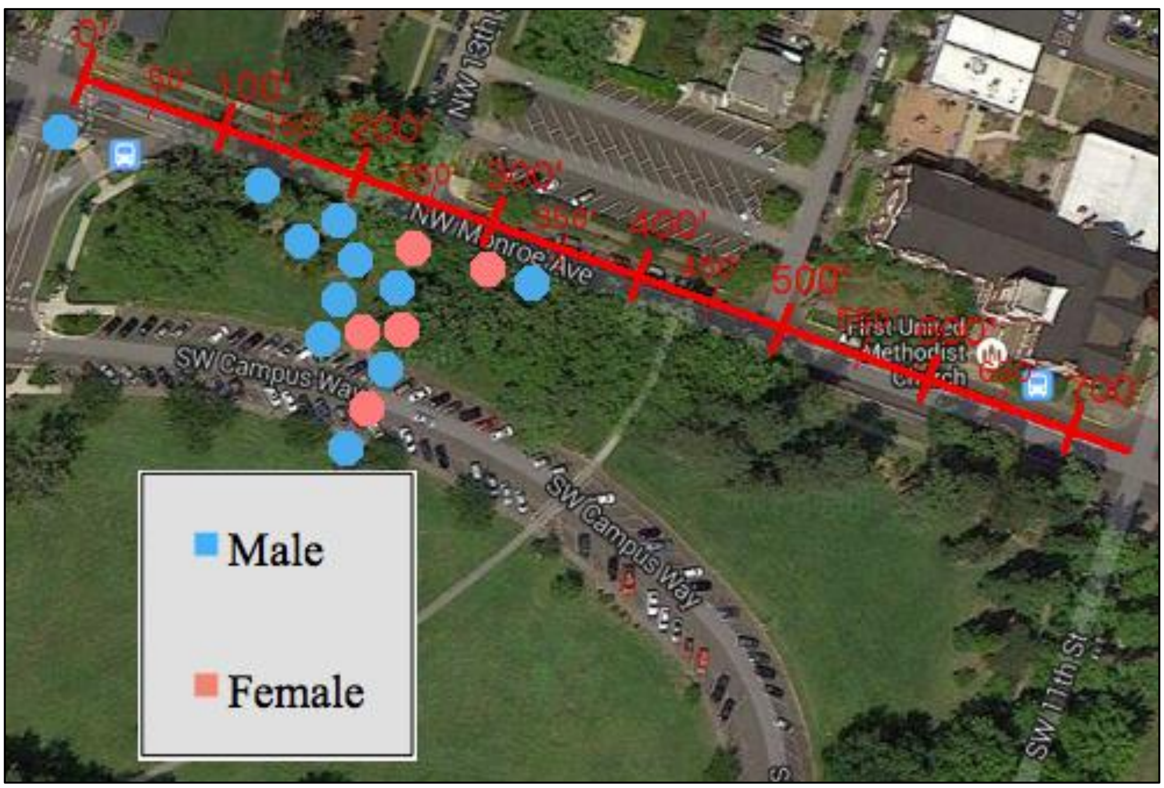

Figure A14: 14th and Monroe - Lane Merge vs. Gender

Appendix B: Questionnaire Data

Visual Search Patterns of Left Turning Bicyclists at Roadway Intersections: A Field Study

Post-bike survey questions:

Q1: What is your sex?
- ☐ Male
- ☐ Female
- ☐ Do not wish to identify

Q2: How old are you? ______________(Fill in the blank)

Q3: Do you wear contact lenses?
- ☐ Yes; contact lenses
- ☐ No I do not wear contact lenses

Q4: How would you rate your biking experience?
- ☐ Beginner
- ☐ Novice
- ☐ Skilled
- ☐ Advanced
- ☐ Expert

Q5: Estimate how many miles do you ride weekly? ______________(Fill in the blank)

Q6: Estimate how many miles do you drive weekly? ______________(Fill in the blank)

Q7: Estimate how many miles do you walk weekly? ______________(Fill in the blank)

*Please continue on the back page for a few more questions

Figure B1: Questionnaire Page 1/2

Q8: Please answer the following questions by marking each box with an X.

Question	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
I use a bike as my primary mode of transportation during weekdays					
I use a bike as my primary mode of transportation during weekends					
While riding a bike, I use appropriate signals when turning					
While riding a bike, I wear a helmet					
While riding a bike, I wear reflective clothing and/or use lights at night					
I walk my bike across cross walks					
I am comfortable riding a bike in a shared lane with vehicles					
I am comfortable riding a bike in a bike lane adjacent to a vehicle lane					
I ride my bike not only in Corvallis, but at home or other places as well (ex. Portland)					
I cycle competively					

Figure B2: Questionnaire Page 2/2

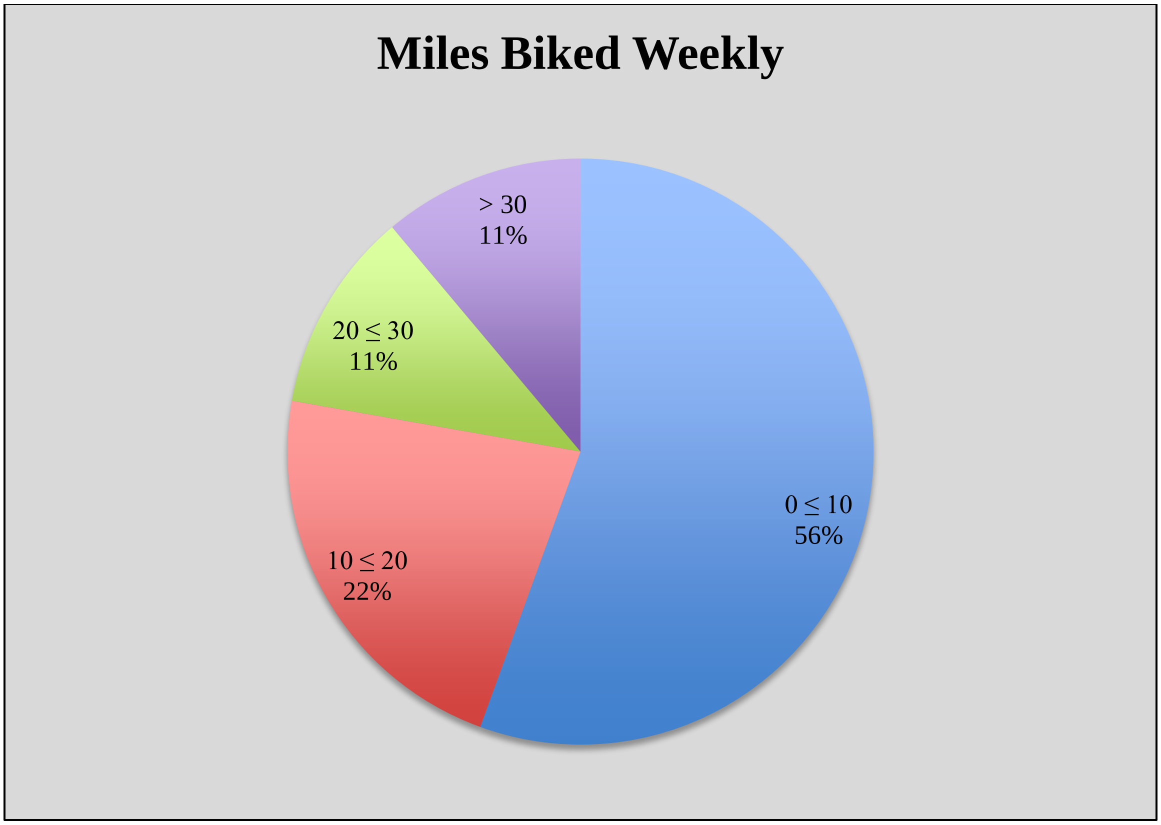

Figure B3: Miles Biked Weekly

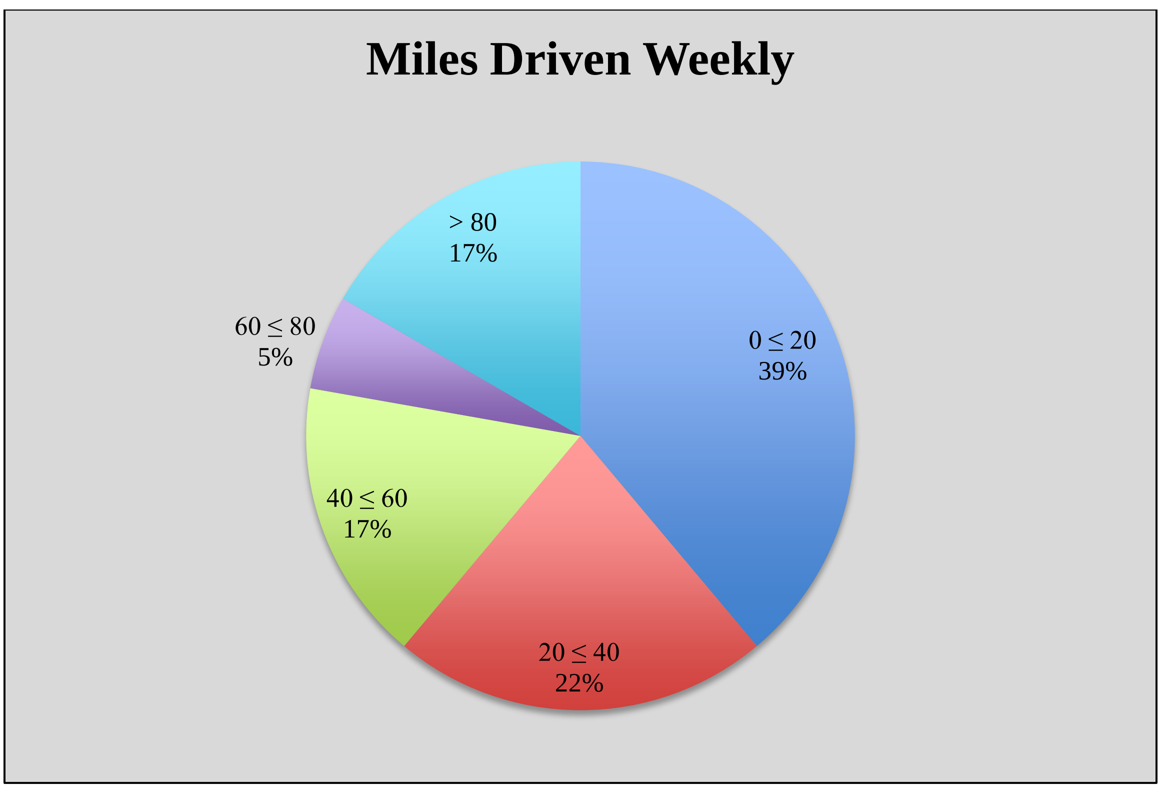

Figure B4: Miles Driven Weekly

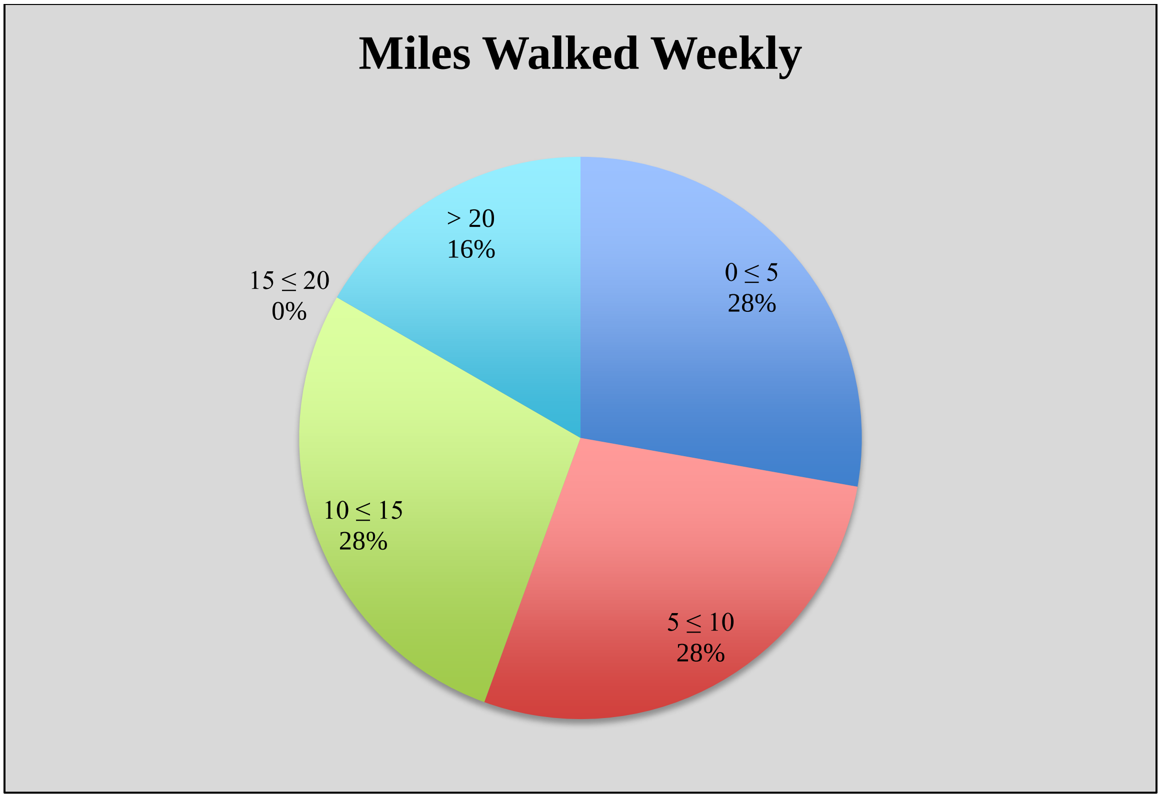

Figure B5: Miles Walked Weekly

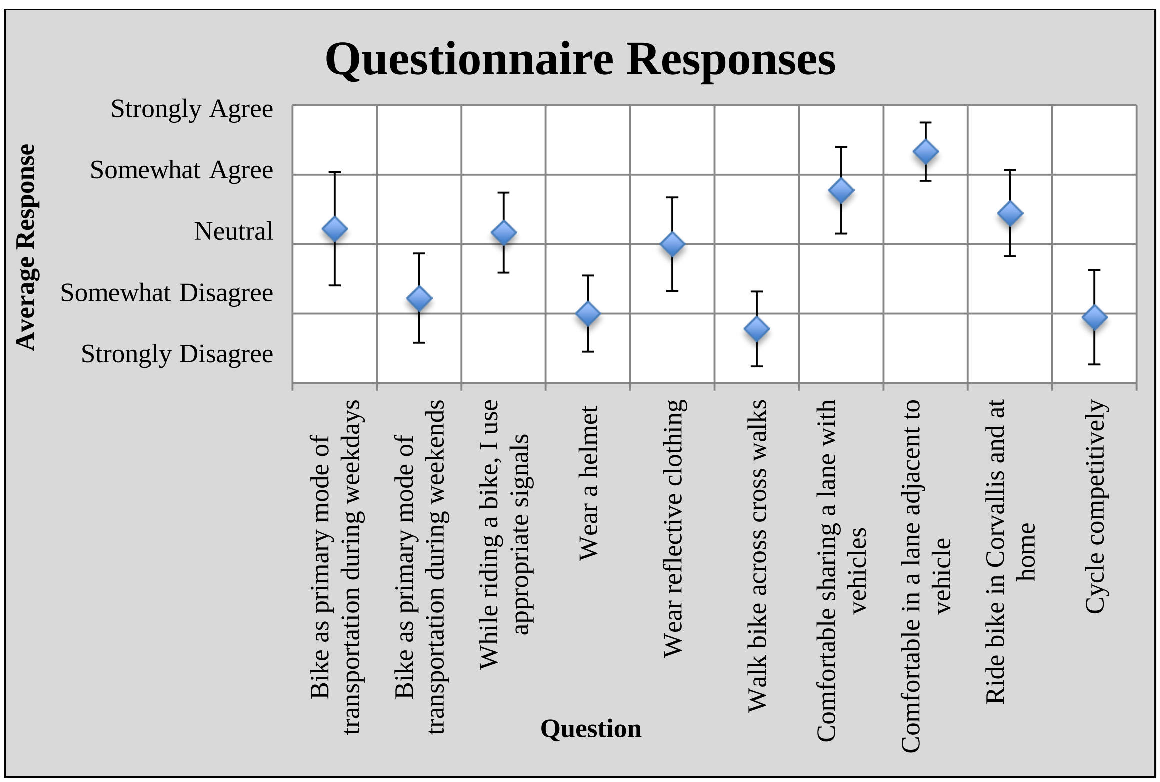

Figure B6: Questionnaire Responses with 95% CI

Appendix C: StatPlus ANOVA

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
Left – 14th and Jefferson	18	30.	1.66667	1.17647		
Right – 14th and Jefferson	18	21.	1.16667	1.32353		
Left – 11th and Jefferson	18	24.	1.33333	0.47059		
Right – 11th and Jefferson	18	15.	0.83333	0.5		
Left – 11th and Monroe	18	53.	2.94444	1.82026		
Right – 11th and Monroe	18	46.	2.55556	1.43791		
Left – 14th and Monroe	18	29.	1.61111	1.78105		
Right – 14th and Monroe	18	17.	0.94444	0.52614		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	71.88194	7	10.26885	9.09155	**0.**	2.07756

Figure C1: ANOVA Analysis of Left vs. Right Glances

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
Left – 14th and Jefferson	18	30.	1.66667	1.17647		
Left – 11th and Jefferson	18	24.	1.33333	0.47059		
Left – 11th and Monroe	18	53.	2.94444	1.82026		
Left – 14th and Monroe	18	29.	1.61111	1.78105		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	27.88889	3	9.2963	7.0851	**0.00033**	2.7395

Figure C2: ANOVA Analysis of Left Glances vs. Intersections

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
Right – 14th and Jefferson	18	21.	1.16667	1.32353		
Right – 11th and Jefferson	18	15.	0.83333	0.5		
Right – 11th and Monroe	18	46.	2.55556	1.43791		
Right – 14th and Monroe	18	17.	0.94444	0.52614		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	34.48611	3	11.49537	12.14006	**0.**	2.7395

Figure C3: ANOVA Analysis of Right Glances vs. Intersections

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
Left – Novice – 14th and Jefferson	7	11.	1.57143	1.61905		
Left – Intermediate – 14th and Jefferson	6	10.	1.66667	1.46667		
Left – Advanced – 14th and Jefferson	4	8.	2.	0.66667		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	0.48179	2	0.2409	0.17706	**0.83958**	3.73889

Figure C4: ANOVA Analysis of 14th and Jefferson - Left Glances vs. Experience

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
Right – Novice – 14th and Jefferson	7	8.	1.14286	1.47619		
Right – Intermediate – 14th and Jefferson	6	9.	1.5	2.3		
Right – Advanced – 14th and Jefferson	4	4.	1.	0.E+0		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	0.70168	2	0.35084	0.24128	**0.78882**	3.73889

Figure C5: ANOVA Analysis of 14th and Jefferson - Right Glances vs. Experience

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
Left – Novice – 11th and Jefferson	7	9.	1.28571	0.57143		
Left – Intermediate – 11th and Jefferson	6	7.	1.16667	0.16667		
Left – Advanced – 11th and Jefferson	4	7.	1.75	0.91667		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	0.87045	2	0.43522	0.86897	**0.44082**	3.73889

Figure C6: ANOVA Analysis of 11th and Jefferson - Left Glances vs. Experience

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
Right – Novice – 11th and Jefferson	7	5.	0.71429	0.90476		
Right – Intermediate – 11th and Jefferson	6	6.	1.	0.4		
Right – Advanced – 11th and Jefferson	4	4.	1.	0.E+0		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	0.33613	2	0.16807	0.31674	**0.7336**	3.73889

Figure C7: ANOVA Analysis of 11th and Jefferson - Right Glances vs. Experience

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
Left – Novice – 11th and Monroe	7	23.	3.28571	1.57143		
Left – Intermediate – 11th and Monroe	6	15.	2.5	3.1		
Left – Advanced – 11th and Monroe	4	13.	3.25	0.91667		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	2.32143	2	1.16071	0.5871	**0.56906**	3.73889

Figure C8: ANOVA Analysis of 11th and Monroe - Left Glances vs. Experience

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
Right – Novice – 11th and Monroe	7	20.	2.85714	0.80952		
Right – Intermediate – 11th and Monroe	6	13.	2.16667	2.96667		
Right – Advanced – 11th and Monroe	4	11.	2.75	0.91667		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	1.67717	2	0.83859	0.52317	**0.60378**	3.73889

Figure C9: ANOVA Analysis of 11th and Monroe - Right Glances vs. Experience

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
Left – Novice – 14th and Monroe	7	6.	0.85714	0.47619		
Left – Intermediate – 14th and Monroe	6	11.	1.83333	2.16667		
Left – Advanced – 14th and Monroe	4	10.	2.5	3.		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	7.42717	2	3.71359	2.29128	**0.13777**	3.73889

Figure C10: ANOVA Analysis of 14th and Monroe - Left Glances vs. Experience

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
Right – Novice – 14th and Monroe	7	4.	0.57143	0.28571		
Right – Intermediate – 14th and Monroe	6	7.	1.16667	0.96667		
Right – Advanced – 14th and Monroe	4	5.	1.25	0.25		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	1.64356	2	0.82178	1.57653	**0.24127**	3.73889

Figure C11: ANOVA Analysis of 14th and Monroe - Right Glances vs. Experience

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
14th and Jefferson	18	27.	1.5	1.20588		
11th and Jefferson	18	29.	1.61111	1.19281		
11th and Monroe	18	5.	0.27778	0.21242		
14th and Monroe	18	20.	1.11111	0.57516		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	19.70833	3	6.56944	8.24718	**0.00009**	2.7395

Figure C12: ANOVA Analysis of Total Glances Back vs. Intersections

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
14th and Jefferson - Novice	7	9.	1.28571	0.90476		
14th and Jefferson - Intermediate	6	13.	2.16667	2.16667		
14th and Jefferson - Advanced	4	4.	1.	0.E+0		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	3.97339	2	1.98669	1.71036	**0.21649**	3.73889

Figure C13: ANOVA Analysis of 14th and Jefferson - Total Glances Back vs. Experience

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
11th and Jefferson - Novice	7	12.	1.71429	2.2381		
11th and Jefferson - Intermediate	6	11.	1.83333	0.96667		
11th and Jefferson - Intermediate	4	5.	1.25	0.25		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	0.87045	2	0.43522	0.32049	**0.73098**	3.73889

Figure C14: ANOVA Analysis of 11th and Jefferson - Total Glances Back vs. Experience

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
11th and Monroe - Novice	7	1.	0.14286	0.14286		
11th and Monroe - Intermediate	6	3.	0.5	0.3		
11th and Monroe - Intermediate	4	1.	0.25	0.25		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	0.42227	2	0.21113	0.95132	**0.40984**	3.73889

Figure C15: ANOVA Analysis of 11th and Monroe - Total Glances Back vs. Experience

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
14th and Monroe - Novice	7	5.	0.71429	0.2381		
14th and Monroe - Intermediate	6	9.	1.5	1.1		
14th and Monroe - Intermediate	4	5.	1.25	0.25		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	2.08613	2	1.04307	1.90178	**0.18593**	3.73889

Figure C16: ANOVA Analysis of 14th and Monroe - Total Glances Back vs. Experience

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
14th and Jefferson	17	337.98893	19.8817	45.32488		
11th and Jefferson	17	194.82867	11.46051	24.69672		
14th and Monroe	15	228.4216	15.22811	22.73193		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	604.8326	2	302.4163	9.66997	**0.00031**	3.19958

Figure C17: ANOVA Analysis of First Glances vs. Intersections

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
Novice – 14th and Jefferson	6	112.935	18.8225	69.5436		
Novice – 11th and Jefferson	6	63.51867	10.58644	22.54458		
Novice – 14th and Monroe	5	76.7676	15.35352	18.94148		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	204.98464	2	102.49232	2.67601	**0.10371**	3.73889

Figure C18: ANOVA Analysis of First Glance vs. Novice Experience

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
Intermediate – 14th and Jefferson	6	142.27321	23.7122	27.27814		
Intermediate – 11th and Jefferson	6	88.74867	14.79144	27.37315		
Intermediate – 14th and Monroe	5	80.726	16.1452	10.63516		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	272.8025	2	136.40125	6.04698	**0.0128**	3.73889

Figure C19: ANOVA Analysis of First Glance vs. Intermediate Experience

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
Advanced – 14th and Jefferson	4	70.675	17.66875	22.08897		
Advanced – 11th and Jefferson	4	35.14	8.785	9.81859		
Advanced – 14th and Monroe	4	61.196	15.299	55.14305		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	169.2919	2	84.64595	2.91713	**0.10553**	4.25649

Figure C20: ANOVA Analysis of First Glance vs. Advanced Experience

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
Male – 14th and Jefferson	11	207.36143	18.85104	23.97498		
Male – 11th and Jefferson	11	114.37267	10.39752	13.88817		
Male – 14th and Monroe	10	141.206	14.1206	26.13988		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	394.78548	2	197.39274	9.32477	**0.00075**	3.32765

Figure C21: ANOVA Analysis of First Glance vs. Male Gender

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
Female – 14th and Jefferson	6	130.6275	21.77125	90.4682		
Female – 11th and Jefferson	6	80.456	13.40933	44.20975		
Female – 14th and Monroe	5	87.2156	17.44312	11.54773		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	209.8414	2	104.9207	2.04131	**0.16675**	3.73889

Figure C22: ANOVA Analysis of First Glance vs. Female Gender

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
14th and Jefferson - Novice	6	112.935	18.8225	69.5436		
14th and Jefferson - Intermediate	6	142.27321	23.7122	27.27814		
14th and Jefferson - Advanced	4	70.675	17.66875	22.08897		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	110.57736	2	55.28868	1.30593	**0.30421**	3.80557

Figure C23: ANOVA Analysis of 14th and Jefferson - First Glance vs. Experience

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
11th and Jefferson - Novice	6	63.51867	10.58644	22.54458		
11th and Jefferson - Intermediate	6	88.74867	14.79144	27.37315		
11th and Jefferson - Advanced	4	35.14	8.785	9.81859		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	98.76842	2	49.38421	2.30069	**0.1395**	3.80557

Figure C24: ANOVA Analysis of 11th and Jefferson - First Glance vs. Experience

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
14th and Monroe - Novice	5	76.7676	15.35352	18.94148		
14th and Monroe - Intermediate	5	80.726	16.1452	10.63516		
14th and Monroe - Advanced	4	61.196	15.299	55.14305		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	2.14639	2	1.0732	0.04161	**0.9594**	3.9823

Figure C25: ANOVA Analysis of 14th and Monroe - First Glance vs. Experience

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
14th and Jefferson	16	205.51786	12.84487	22.89795		
11th and Jefferson	16	95.26333	5.95396	11.67751		
14th and Monroe	15	147.6356	9.84237	2.76163		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	381.88077	2	190.94038	15.07529	**0.00001**	3.20928

Figure C26: ANOVA Analysis of Lane Merge vs. Intersections

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
Novice – 14th and Jefferson	6	88.29607	14.71601	50.1502		
Novice – 11th and Jefferson	6	37.118	6.18633	24.01366		
Novice – 14th and Monroe	5	53.6464	10.72928	2.31478		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	218.53923	2	109.26961	4.02489	**0.0416**	3.73889

Figure C27: ANOVA Analysis of Lane Merge vs. Novice Experience

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
Intermediate – 14th and Jefferson	5	61.56964	12.31393	11.9696		
Intermediate – 11th and Jefferson	6	38.436	6.406	7.27964		
Intermediate – 14th and Monroe	5	46.392	9.2784	2.02549		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	95.31187	2	47.65593	6.70639	**0.00997**	3.80557

Figure C28: ANOVA Analysis of Lane Merge vs. Intermediate Experience

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
Advanced – 14th and Jefferson	4	46.095	11.52375	1.54424		
Advanced – 11th and Jefferson	3	13.90133	4.63378	5.94811		
Advanced – 14th and Monroe	4	39.4872	9.8718	4.25792		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	85.68783	2	42.84392	11.69692	**0.00422**	4.45897

Figure C29: ANOVA Analysis of Lane Merge vs. Advanced Experience

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
Male – 14th and Jefferson	10	113.60071	11.36007	3.16445		
Male – 11th and Jefferson	10	60.05533	6.00553	7.56251		
Male – 14th and Monroe	10	92.6284	9.26284	2.77749		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	145.59835	2	72.79917	16.17225	**0.00002**	3.35413

Figure C30: ANOVA Analysis of Lane Merge vs. Male Gender

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
Female – 14th and Jefferson	6	91.91714	15.31952	51.23988		
Female – 11th and Jefferson	6	35.208	5.868	21.40583		
Female – 14th and Monroe	5	55.0072	11.00144	0.89739		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	268.5805	2	134.29025	5.12533	**0.02137**	3.73889

Figure C31: ANOVA Analysis of Lane Merge vs. Female Gender

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
14th and Jefferson - Novice	6	88.29607	14.71601	50.1502		
14th and Jefferson - Intermediate	5	61.56964	12.31393	11.9696		
14th and Jefferson - Advanced	4	46.095	11.52375	1.54424		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	28.67738	2	14.33869	0.56738	**0.58151**	3.88529

Figure C32: ANOVA Analysis of 14th and Jefferson - Lane Merge vs. Experience

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
11th and Jefferson - Novice	6	37.118	6.18633	24.01366		
11th and Jefferson - Intermediate	6	38.436	6.406	7.27964		
11th and Jefferson - Advanced	3	13.90133	4.63378	5.94811		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	6.77725	2	3.38862	0.24152	**0.78916**	3.88529

Figure C33: ANOVA Analysis of 11th and Jefferson - Lane Merge vs. Experience

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
14th and Monroe - Novice	5	53.6464	10.72928	2.31478		
14th and Monroe - Intermediate	5	46.392	9.2784	2.02549		
14th and Monroe - Advanced	4	39.4872	9.8718	4.25792		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	5.31244	2	2.65622	0.96959	**0.40942**	3.9823

Figure C34: ANOVA Analysis of 14th and Monroe - Lane Merge vs. Experience

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
14th and Jefferson	17	53.68643	3.15803	4.07353		
11th and Jefferson	16	50.18067	3.13629	4.81414		
14th and Monroe	15	41.3308	2.75539	5.89967		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	1.58937	2	0.79469	0.16256	**0.85046**	3.20432

Figure C35: ANOVA Analysis of Last Glance to Lane Merge vs. Intersections

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
Novice – 14th and Jefferson	6	21.38607	3.56435	6.12869		
Novice – 11th and Jefferson	6	18.17267	3.02878	2.06082		
Novice – 14th and Monroe	5	23.1212	4.62424	11.83837		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	7.0819	2	3.54095	0.56141	**0.58273**	3.73889

Figure C36: ANOVA Analysis of Last Glance to Lane Merge vs. Novice Experience

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
Intermediate – 14th and Jefferson	6	20.33393	3.38899	5.7917		
Intermediate – 11th and Jefferson	6	23.98667	3.99778	10.12986		
Intermediate – 14th and Monroe	5	7.6084	1.52168	0.26716		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	17.75762	2	8.87881	1.54076	**0.24843**	3.73889

Figure C37: ANOVA Analysis of Last Glance to Lane Merge vs. Intermediate Experience

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
Advanced – 14th and Jefferson	4	9.41786	2.35446	0.43655		
Advanced – 11th and Jefferson	3	6.408	2.136	0.70758		
Advanced – 14th and Monroe	4	8.9792	2.2448	2.25756		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	0.08247	2	0.04124	0.03473	**0.96601**	4.45897

Figure C38: ANOVA Analysis of Last Glance to Lane Merge vs. Advanced Experience

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
Male – 14th and Jefferson	11	34.58179	3.1438	4.76107		
Male – 11th and Jefferson	10	26.92267	2.69227	4.93298		
Male – 14th and Monroe	10	23.5016	2.35016	2.06763		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	3.33598	2	1.66799	0.42221	**0.6597**	3.34039

Figure C39: ANOVA Analysis of Last Glance to Lane Merge vs. Male Gender

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
Female – 14th and Jefferson	6	19.10464	3.18411	3.51191		
Female – 11th and Jefferson	6	23.258	3.87633	4.51153		
Female – 14th and Monroe	5	17.8292	3.56584	14.76512		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	1.44201	2	0.721	0.10178	**0.90389**	3.73889

Figure C40: ANOVA Analysis of Last Glance to Lane Merge vs. Female Gender

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
14^{th} and Jefferson - Novice	6	21.38607	3.56435	6.12869		
14^{th} and Jefferson - Intermediate	6	20.33393	3.38899	5.7917		
14^{th} and Jefferson - Advanced	4	9.41786	2.35446	0.43655		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	3.87026	2	1.93513	0.413	**0.67004**	3.80557

Figure C41: ANOVA Analysis of 14^{th} and Jefferson - Last Glance to Lane Merge vs. Experience

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
11^{th} and Jefferson - Novice	6	18.17267	3.02878	2.06082		
11^{th} and Jefferson - Intermediate	6	23.98667	3.99778	10.12986		
11^{th} and Jefferson - Advanced	3	6.408	2.136	0.70758		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	7.36943	2	3.68471	0.70896	**0.51166**	3.88529

Figure C42: ANOVA Analysis of 11^{th} and Jefferson - Last Glance to Lane Merge vs. Experience

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
14^{th} and Monroe - Novice	5	23.1212	4.62424	11.83837		
14^{th} and Monroe - Intermediate	5	7.6084	1.52168	0.26716		
14^{th} and Monroe - Advanced	4	8.9792	2.2448	2.25756		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	***p-level***	*F crit*
Between Groups	26.02426	2	13.01213	2.59324	**0.11949**	3.9823

Figure C43: ANOVA Analysis of 14^{th} and Monroe - Last Glance to Lane Merge vs. Experience