

Copyright
by
Weijun Zhang
2014

**The Report Committee for Weijun Zhang
Certifies that this is the approved version of the following report:**

Cycle Tracks Evaluation in West Campus in Austin, Texas

**APPROVED BY
SUPERVISING COMMITTEE:**

Supervisor:

Junfeng Jiao

Sarah Dooling

Cycle Tracks Evaluation in West Campus in Austin, Texas

by

Weijun Zhang, B.S.

Report

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

Master of Science in Community and Regional Planning

The University of Texas at Austin

May, 2014

Dedication

I would like to dedicate this report to my parents and grandmother who stand by me and respect every decision I made in my life; to my friends who encourage me and help me when I feel depressed; to my lovely dog who accompany my parents when I am away from home. Thank you for making me feel that I am never alone and I could be a person who achieves happiness.

Acknowledgements

I would like to express my sincere gratitude to my advisors, Dr. Junfeng Jiao and Dr. Sarah Dooling, for their patience, motivation, enthusiasm, and immense knowledge. Thank you to the Community and Regional Planning Program for providing me such a wonderful learning experience in Austin. Finally, I am grateful to my friends, classmates, colleagues, and teachers who worked with me on same projects, answered my questions, and gave me comments.

Abstract

Cycle Tracks Evaluation in West Campus in Austin, Texas

Weijun Zhang, M.S.C.R.P.

The University of Texas at Austin, 2014

Supervisor: Junfeng Jiao

This research evaluated the performance of two types of cycle tracks—a one-way cycle track on Guadalupe St. and a two-way cycle track on Rio Grande St. in West Campus. The evaluation focused on all types of traffic users' (including bicyclists, pedestrians and motorists) behavior and their perspectives regarding safety, comfort and operation. For each cycle track, all users' behavior and their interactions with others was observed at the main intersection for a cumulative 4 hours; and 35 intercept surveys, including 15 cyclist surveys, 10 pedestrian surveys and 10 motorist surveys, were collected to identify all types of traffic users' experiences, perceptions and attitudes toward the cycle tracks. Overall, the results indicate that the cycle tracks have improved the sense of safety and comfort for cyclists, but, at the same time, other people—including pedestrians—misuse the space, resulting in potential safety issues with the existing intersection design that might undermine overall success.

Table of Contents

List of Tables	x
List of Figures	xii
Chapter I: <i>Introduction</i>	1
Chapter II: <i>Literature Review</i>	3
2.1 The Role of Cycling in Sustainable Transportation.....	3
2.2 Why we need bicycle infrastructures?	4
2.3 Bicycle Infrastructure and University Commuting.....	5
2.4 Controversies Over Cycle Track Safety	7
2.5 Two-Way Cycle Track.....	9
2.6 Research Questions	10
Chapter III: <i>Methods</i>	11
3.1 Settings.....	11
3.2 Locations Selection.....	11
3.2.1 Guadalupe St. from West 24th St. to Martin Luther King Jr. Blvd.: One-Way Cycle Track	12
3.2.2 Rio Grande St. from West 24th St. to Martin Luther King Jr. Blvd.: Two-Way Cycle Track.....	13
3.3 Data Collection	13
3.3.1 Multi-Modal Behavior Observation.....	13
3.3.2 Intercept Survey	14
3.4 Data Analysis	15
3.5 Limitations	15
Chapter IV: <i>Data Analysis & Results</i>	17
4.1 Evaluation of One-Way Cycle Track on Guadalupe St.	17
4.1.1 Observation Analysis.....	17
a. Cyclist Counts	17
b. Usage Rate	17

c. Encroachment.....	18
d. Signal Compliance.....	19
e. Cyclist Collisions and Near-Collisions	20
4.1.2 Cyclist Survey Analysis.....	20
a. Respondents' Characteristics.....	20
b. Understanding and Compliance.....	21
c. Perception of Safety and Ease.....	22
d. Collisions, Near-Collisions & Potential Conflicts.....	23
e. Attitude and Recommendations	25
4.1.3 Pedestrian Survey Analysis.....	26
a. Respondents' Characteristics.....	26
b. Understanding and Compliance.....	26
c. Collisions and Near-Collisions	26
d. Perceptions on Pedestrians Environment.....	26
4.1.4 Motorist Survey Analysis	27
a. Respondents' Characteristics.....	27
b. Experience with Cycle Track.....	28
4.1.5 Main Findings	29
4.2 Evaluation of Two-Way Cycle Track on Rio Grande St.	32
4.2.1 Observation Analysis.....	32
a. Cyclist Counts	32
b. Usage Rate	32
c. Encroachment.....	33
d. Cyclist Collisions and Near-Collisions.....	36
4.2.2 Cyclist Survey Analysis.....	36
a. Respondents' Characteristics.....	36
b. Understanding and Compliance.....	37
c. Perception of Safety and Ease.....	37
d. Collisions, Near-Collisions & Potential Conflicts.....	39
e. Attitude and Recommendations	40

4.2.3 Pedestrian Survey Analysis.....	41
a. Respondents' Characteristics.....	41
b. Collisions and Near-Collisions	41
c. Perceptions on Pedestrians Environment.....	42
4.2.4 Motorist Survey Analysis	43
a. Respondents' Characteristics.....	43
b. Experience with Cycle Track.....	43
4.2.5 Main Findings	44
Chapter V: Conclusion	47
Appendix A: Cycle Track Multi-Modal Behavior Count Form	51
Appendix B: Bicyclist Intercept Survey (Guadalupe St.).....	52
Appendix C: Pedestrian Intercept Survey (Guadalupe St.)	54
Appendix D: Motorist Intercept Survey (Guadalupe St.).....	55
Appendix E: Bicyclist Intercept Survey (Rio Grande St.).....	56
Appendix F: Pedestrian Intercept Survey (Rio Grande St.).....	58
Appendix G: Motorist Intercept Survey (Rio Grande St.).....	59
Bibliography	60

List of Tables

Table 3.1:	Observation Data Collection Summary.	14
Table 4.1:	Cycling Traffic Volume on Southbound Guadalupe St.	17
Table 4.2:	Usage Rate of Cycle Track, Sidewalk and Vehicle Lane by Cyclists on Southbound Guadalupe St.....	18
Table 4.3:	Encroachments in the Cycle Track on Southbound Guadalupe St. ..	19
Table 4.4:	Cyclist Signal Compliance and Violations at the Intersections Observed.	20
Table 4.5:	Age and Gender Distribution of Cyclist Survey on Guadalupe St. ..	20
Table 4.6:	Self-Reported Understanding and Compliance by Cyclists on Guadalupe St.	22
Table 4.7:	Sense of Safety and Ease of Riding on Guadalupe St.	23
Table 4.8:	Self-Reported Collisions and Near-Collisions on Guadalupe St.	24
Table 4.9:	Self-Reported Frequency of Cycle Track Encounters on Guadalupe St.	24
Table 4.10:	Cyclists Attitude towards the Cycle Track on Guadalupe St.....	25
Table 4.11:	Age and Gender Distribution of Pedestrian Survey on Guadalupe St.	26
Table 4.12:	Perceptions on Pedestrians Environment on Guadalupe St.	27
Table 4.12:	Age and Gender Distribution of Motorist Survey on Guadalupe St.	28
Table 4.13:	Motorist Experience with Cycle Track on Guadalupe St.	29
Table 4.14:	Cycling Traffic Volume on Rio Grande St.	32
Table 4.15:	Usage Rate of Cycle Track, Sidewalk and Vehicle Lane by Cyclists on Rio Grande St.....	33
Table 4.16:	Encroachments in the Cycle Track on Rio Grande St.	34

Table 4.17: Age and Gender Distribution of Cyclist Survey on Rio Grande St. .	36
Table 4.18: Self-Reported Understanding and Compliance by Cyclists on Rio Grande St.	37
Table 4.19: Sense of Safety and Ease of Riding on Rio Grande St.	38
Table 4.20: Self-Reported Collisions and Near-Collisions on Rio Grande St.	39
Table 4.21: Self-Reported Frequency of Cycle Track Encounters on Rio Grande St.	40
Table 4.22: Cyclists Attitude towards the Cycle Track on Rio Grande St.	41
Table 4.23: Age and Gender Distribution of Pedestrian Survey on Rio Grande St.	41
Table 4.24: Perceptions on Pedestrians Environment on Rio Grande St.	42
Table 4.25: Age and Gender Distribution of Motorist Survey on Rio Grande St.	43
Table 4.26: Motorist Experience with Cycle Track on Rio Grande St.	44
Table 5.1: Usage Rate of Cycle Track, Sidewalk and Vehicle Lane by Cyclists on Guadalupe St. and Rio Grande St.	48
Table 5.2: Encroachment in Cycle Tracks on Guadalupe St. and Rio Grande St.	49

List of Figures

Figure 3.1: Bike Routes Use Rating in West Campus.....	11
Figure 3.2: Bike Routes Types in West Campus.....	12
Figure 4.1: Self-Reported Frequency of Cycling on Guadalupe St. before and after the Cycle Track Installation.	21
Figure 4.2: Pedestrian and Vehicle Encroachments in the Cycle Track on Rio Grande St.	35
Figure 4.3: Self-Reported Frequency of Cycling in the Cycle Track on Rio Grande St.	37

Chapter I: *Introduction*

Austin is one of the fastest growing cities in the United States. Many major roads can barely accommodate cars during peak commute times, so the city is seeking a solution to the problem of traffic congestion by attempting to increase bicycle use. Austin has several features that make it a good candidate for increased bicycle use. It has a high young population, a major university and several higher education institutions, a mild climate except in summer, and development designs that increasingly are accommodating different forms of bicycle infrastructure. However, according to American Community Survey data 5-year projection 2008-2012, less than 3% of work commute trips were by bicycle; bicycle and pedestrian deaths in Austin due to collisions with cars were twice the average annual death toll of the past eight years; and a 2013 study shows that over half of Austinites are interested in bicycling, but are concerned about mixing with high-speed motor vehicle traffic.¹ Therefore, the City of Austin is taking steps to build an all-ages and-abilities bikeway network connecting Austin through neighborhood streets, urban trails, and on major streets via "cycle tracks" to allow more people to ride safely and comfortably.²

"Cycle Tracks," sometimes called "Protected Bikeways" or "Green Lanes," are physically separated bike facilities that run alongside a roadway. They provide space that is intended to be exclusively or primarily for bicycles. Commonly, cycle tracks are separated from vehicle travel lanes, parking lanes and sidewalks by pavement markings/coloring, bollards, curbs, medians, landscape buffers or a combination of these

¹ "Changing Lanes: Austin's Cycle Tracks," BIKEAUSTIN, accessed Dec 8, 2013, <http://bikeaustin.org/education/changing-lanes-austins-cycle-tracks/>.

² "Changing Lanes," BIKEAUSTIN, accessed Dec 8, 2013, <http://bikeaustin.org/wp-content/uploads/2013/09/Bike-Austin-Cycle-Tracks-Changing-Lanes-brochure-2013-10.pdf>.

elements. A cycle track may be one-way, placed on each side of the street, or two-way and placed on one or both sides of the street. Austin, along with Chicago, Memphis, Portland, San Francisco and Washington, is one of the six focus US cities in the first round of the PeopleForBikes Green Lane Project's separated bicycle facilities across the city. The goal of the Green Lane Project is to create "low-stress streets and increase vitality in urban centers through the installation of protected bike lanes."³ With the help of the Green Lane Project, the city implemented 5.46-mile cycle tracks on 7 major connections in the downtown area by the end of 2013, two of which were built on Guadalupe St. and Rio Grande St. in West Campus, a high-density neighborhood in central Austin heavily populated by college students.

As a newly emerging bicycle infrastructure in US, however, cycle track safety remains unproven.⁴ This paper presents the results of an evaluation of cycle tracks at two locations in West Campus in Austin, with the main focus on all types of traffic users' (including bicyclists, pedestrians and motorists) behavior and their perspectives regarding safety, comfort and operations. The aim is to assess whether the cycle tracks are achieving their objectives, and whether there are any unintended negative impacts.

³ "Green Lane Project," peopleforbikes, accessed Mar 16, 2014, <http://www.peopleforbikes.org/green-lane-project/pages/about-the-project>.

⁴ Schimek, P., "Cycle Track Safety Remains Unproven," *American Journal of Public Health* 103, no.10 (2013): e6-e7.

Chapter II: *Literature Review*

2.1 THE ROLE OF CYCLING IN SUSTAINABLE TRANSPORTATION

The current urban mobility problems have reached a critical stage. The exponential increase in the amount of urban traffic not only makes congestion a huge worldwide problem for many major cities but also leads to the rise of carbon dioxide emissions that affect the health of people and contribute to global warming and climate change. The idea of sustainable transportation was put forward under such a background. As defined by Black, sustainable transportation is "satisfying current transport and mobility needs without compromising the ability of future generations to meet these needs."⁵

The role of cycling in advancing sustainable transportation in urban area has gained more and more attention from researchers, planners and policy-makers. Many urban planners, community activists and environmental organizations support cycling because it can "contribute to the mitigation of carbon dioxide emissions since cycling possesses an intrinsic zero-emission value"⁶ (ignoring life cycle assessment and commodity chain analysis) and some transport planners view bicycles as much more space-efficient than cars and a way to reduce roadway congestion. The low public cost of bicycle transportation, compared to motorized transport, is another big reason that many cities promote cycling commuting. Apart from the public cost, cycling itself is also cheaper than any mode except walking and thus more affordable to even the poor.⁷

⁵ Black, W. R., "Sustainable transportation: a US perspective," *Journal of Transport Geography* 4 (1996): 151-159.

⁶ Massink, R., Zuidgeest, M., Rijnsburger, J., Sarmiento, O. L. and van Maarseveen, M." The Climate Value of Cycling," *Natural Resources Forum* 35 (2011): 100-111.

⁷ Pucher, J., Komanoff, C. and Schimek, P. "Bicycling Renaissance in North America? Recent Trends and Alternative Policies to Promote Bicycling," *Transportation Research Part A: Policy and Practice* 33 (1999): 625-654.

Additionally, some medical studies have found that a modal shift from motor vehicle use to active forms of transportation (i.e., walking, cycling, and public transportation) would contribute to health via the daily accumulation of physical activity.^{8 9}

2.2 WHY WE NEED BICYCLE INFRASTRUCTURES?

Although cycling has been proved to improve people's health directly or indirectly, bicyclists generally incur a higher risk of injuries requiring hospitalization than motor vehicle occupants. Meanwhile, the previous study shows that people's perceptions of safety has an important effect on bicycle commuting.¹⁰ Therefore, understanding how to making cycling safer is crucial to increasing rates of cycling.

Bicycle infrastructure has been proved an essential ingredient for improving cyclists' safety in many studies. Reynolds and colleagues reviewed studies of the impact of transportation infrastructure on bicyclist safety and found that purpose-built bicycle-specific facilities could reduce crashes and injuries among cyclists¹¹. In the case of New York City, reduced vehicular speeds and fewer conflicts between vehicles and bicyclists after installation of bicycle infrastructures mainly contributed to the lack of increase in crashes.¹² Through improving the safety conditions for bicyclists, bicycle infrastructure

⁸ Von Huth SL, Borch-Johnsen K and Jørgensen T, "Commuting physical activity is favorably associated with biological risk factors for cardiovascular disease," *Eur J Epidemiol* 22 (2007): 771-779.

⁹ Wagner A, Simon C, Ducimetiere P, Montaye M, Bongrad V, Yarnell J, Bingham A, Hedelin G, Amouyel P and Ferrieres J, "Leisure-time physical activity and regular walking or cycling to work are associated with adiposity and 5y weight gain in middle-aged men: the PRIME study," *Int J Obes* 25 (2001): 940-948.

¹⁰ Willis, D. P., Manaugh, K. and El-Geneidy, A., "Cycling under Influence: Summarizing the influence of attitudes, habits, social environments and perceptions on cycling for transportation." In *92nd Transportation Research Board Annual Meeting, Washington DC, USA*. 2013.

¹¹ Reynolds, C. C., Harris, A. M., Teschke, K., Cripton, P. A. and Winters, M., "The impact of transportation infrastructure on bicycling injuries and crashes: a review of the literature." *Environmental Health* 8, no. 1 (2009): 47.

¹² Chen, L. et al. "Evaluating the Safety Effects of Bicycle Lanes in New York City," *American Journal of Public Health* 102, no.6 (2012): 1120-1127.

shows a significant impact on increasing ridership. Nelson and Allen, who examined 18 U.S. cities' datasets to explain the relationship between bicycle commuting and bicycle pathways, found that cities with higher levels of bicycle infrastructure (lanes and paths) also saw higher levels of bicycle commuting.¹³ This finding was confirmed by Dill and Carr, who analyzed the data from 35 cities across the U.S. expanding upon Nelson and Allen's work. They found that adding a mile of bicycle lanes per square mile in cities correlated with an increase of approximately 1% in the bicycle commuting rate.¹⁴ Their findings supported the assertion that new bicycle lanes in large cities would be used by commuters.

2.3 BICYCLE INFRASTRUCTURE AND UNIVERSITY COMMUTING

Universities usually are where an area's largest numbers of commuters in many communities come from and make frequent trips within a given day.¹⁵ As a result, they can create traffic congestion on the roads servicing the campus and parking problems in neighboring communities.¹⁶ In order to minimize these impacts, universities have the responsibility to implement employer trip reduction programs. Moreover, "due to their pro-active educational milieu, college campuses should also be the privileged places to communicate sustainability and to help reshape society's transportation patterns."¹⁷

¹³ Nelson, A. C., and Allen, D., "If you build them, commuters will use them: association between bicycle facilities and bicycle commuting," *Transportation Research Record: Journal of the Transportation Research Board* 1578, no. 1 (1997): 79-83.

¹⁴ Dill, J. and Carr, T., "Bicycle commuting and facilities in major US cities: if you build them, commuters will use them," *Transportation Research Record: Journal of the Transportation Research Board* 1828, no. 1 (2003): 116-123.

¹⁵ Bustillos, B. I., Shelton, J. and Chiu, Y., "Urban university campus transportation and parking planning through a dynamic traffic simulation and assignment approach," *Transportation Planning and Technology* 34, no. 2 (2011): 177-197.

¹⁶ Brown-West, O. G., "Optimization model for parking in the campus environment," *Transportation Research Record: Journal of the Transportation Research Board* 1564, no. 1 (1996): 46-53.

¹⁷ Balsas, C. JL. "Sustainable transportation planning on college campuses," *Transport Policy* 10, no. 1 (2003): 35-49.

It is known that college students cycle at much higher rates than the general population.¹⁸ They are usually more physically fit, environmentally conscious and receptive to new ideas.¹⁹ More importantly, most of them live close to campus. Staff and faculty members also share some of these characteristics. Thus, bicycling has been widely accepted as a complementary mode of transportation to get to and around campus.

Akar and Clifton examined the opportunities and challenges presented to cyclists on and around the campus of the University of Maryland, College Park, finding that both non-bicycle commuters and bicycle commuters agreed that bicycle lanes, trails, and paths would encourage them to ride a bike (or ride more often) to the campus.²⁰ This result is confirmed by Whannell et, al., who explored the likelihood that tertiary students would use a bicycle to commute to the university and the factors which influenced the decision to bicycle commute in a regional Australian university. Besides the opportunity to ride on bike paths, the results of the study also identified route safety as the primary factor influencing the decision to bicycle commute.²¹ Additionally, bicycling comfort was identified as the key factor that influenced both male and female university employees to commute by bicycle in a study at the University of California, Davis.²²

¹⁸ Pucher, J., Komanoff, C. and Schimek, P., "Bicycling renaissance in North America?: Recent trends and alternative policies to promote bicycling," *Transportation Research Part A: Policy and Practice* 33, no. 7 (1999): 625-654.

¹⁹ Balsas, C. J.L. "Sustainable transportation planning on college campuses." *Transport Policy* 10, no. 1 (2003): 35-49.

²⁰ Akar, G. and Clifton, K. J., "Influence of individual perceptions and bicycle infrastructure on decision to bike," *Transportation Research Record: Journal of the Transportation Research Board* 2140, no. 1 (2009): 165-172.

²¹ Whannell, P., Whannell, R. and White, R., "Tertiary student attitudes to bicycle commuting in a regional Australian university," *International Journal of Sustainability in Higher Education* 13, no. 1 (2012): 34-45.

²² Miller, J. D., and Handy, S. L., "Factors That Influence University Employees to Commute by Bicycle," *Transportation Research Record: Journal of the Transportation Research Board* 2314, no. 1 (2012): 112-119.

2.4 CONTROVERSIES OVER CYCLE TRACK SAFETY

"Cycle Tracks," sometimes called "Protected Bikeways" or "Green Lanes," are commonly found in many European countries. Through separating bike lanes from motor vehicle lanes physically, cycle tracks are believed to increase the perception of safety—or comfort level—of cyclists, thus encouraging more people to ride. Danish research showed that the construction of cycle tracks increased bicycle ridership by 18-20%, compared with the 5-7% increase resulting from marking bicycle lanes.²³ Garrard et al. suggested that improved cycling infrastructures that provide a high degree of separation from motor traffic was important for increasing transportation cycling amongst under-represented population groups—such as women—in Melbourne, Australia.²⁴ Larsen and El-Geneidy examined how specific facility types affected route choice in Montreal, Canada and confirmed Garrard et al.'s finding that there was a high preference for physically-separated facilities among more infrequent cyclists. It suggested that physically-separated facilities was the obvious choice in encouraging new and novice cyclists.²⁵ Although the impact of cycle tracks on promoting bicycle riding has been proved in most research, opinions are mixed on whether cycle tracks can really improve safety.

Some studies show that cycle tracks can reduce crashes, especially fatal or serious crashes. A Danish study found reductions of 35% in cyclist casualties on particular routes, following the construction of cycle tracks or lanes alongside urban roads.²⁶

²³ Jensen, Søren Underlien, Claus Rosenkilde, and Niels Jensen. "Road safety and perceived risk of cycle facilities in Copenhagen." Presentation to AGM of European Cyclists Federation (2007).

²⁴ Garrard, J., Rose, G., and Lo, S.K. "Promoting transportation cycling for women: The role of bicycle infrastructure," *Preventive Medicine* 46, no.1 (2008): 55-59.

²⁵ Larsen, J. and El-Geneidy, A., "A travel behavior analysis of urban cycling facilities in Montréal, Canada," *Transportation research part D: transport and environment* 16, no. 2 (2011): 172-177.

²⁶ Herrstedt, L., *Planning and safety of bicycles in urban area*, No. VTI konferens 9A part 3, 1998.

Teschke et al. compared cycling injury risks of 14 route types and other route infrastructure features in Canada and found that cycle tracks had the lowest injury risk, at about one-ninth the risk of major streets²⁷. In New York City, only 1 of the total of 255 cyclist fatalities in that period occurred on a separated bike lane from 1996 to 2005.²⁸ Additionally, previous studies showed that cycle tracks can also reduce pedestrians' injuries by keeping cyclists off of sidewalks²⁹ and removing the danger of "car dooring" by placing the cycle track on the inside of the parking lane.³⁰

The introduction of cycle tracks reduces the rate of some collisions, while raising others. The results of a large study undertaken by Jensen on before and after observations of newly installed cycle tracks in Copenhagen suggested that "introducing cycle tracks has resulted in three important gains in road safety: fewer accidents in which cars hit or ran over cyclists from the rear, fewer accidents with cyclists turning left and fewer accidents in which cyclists rode into a parked car", but, at the same time, new safety problems, such as "more accidents in which cyclists rode into other cyclists often when overtaking, more accidents with right-turning vehicles and more accidents between cyclists, pedestrians and entering or exiting bus passengers" emerged. The results in Jensen's study shows that although the construction of cycle tracks has resulted in a slight drop in the total number of accidents and injuries on the road sections between junctions,

²⁷ Teschke, K., et al., "Route infrastructure and the risk of injuries to bicyclists: A case-crossover study," *American journal of public health* 102, no. 12 (2012): 2336-2343.

²⁸ New York City Departments of Health and Mental Hygiene, Parks and Recreation, Transportation, and the New York City Police Department, "Bicyclist Fatalities and Serious Injuries in New York City (1996-2005)," accessed Mar 19th, 2014, <http://www.nyc.gov/html/dot/downloads/pdf/bicyclefatalities.pdf>.

²⁹ The City of New York, "Prospect Park West Bicycle Path and Traffic Calming," accessed Mar 19th, 2014, <http://www.nyc.gov/html/dot/html/bicyclists/prospectparkwest.shtml>.

³⁰ Planning, Alta, "Design (2009) Cycle Tracks Lessons Learned," (2009).

the number of accidents and injuries has risen significantly.³¹ "As bicyclists are not traveling directly alongside automobiles, motorists may not be aware of their presence, leading to increased vulnerability at intersections."³² In addition, conflicts with pedestrians and boarding or deboarding bus passengers may occur, if cycle tracks are less-differentiated from sidewalk or are between the sidewalk and a transit stop. In a more recent study conducted by Monsere et al., pedestrians expressed their concerns about interactions with cyclists when crossing the cycle track.³³

2.5 TWO-WAY CYCLE TRACK

Two-way cycle tracks share many similar design characteristics with one-way cycle tracks. They are physically divided from cars and pedestrians, and require similar amenities at driveway and side-street crossings. A 2011 study by Lusk et al. from the Harvard School of Public Health compared bicyclist injury rates on two-way cycle tracks versus in the streets of Montreal and found that two-way cycle tracks provided a 28% lower rate of injury than on-street riding; they were also used by 2.5 times more cyclists than standard streets.³⁴ Evaluation of a bicycle facility in Washington D.C in 2012 also indicated that more bicyclists began traveling along the corridor after the two-way cycle track was installed. On the other hand, the study pointed out that more significant signal modifications would be required at the intersection after the two-way cycle track was

³¹ Jensen, S.U., 2007. Bicycle tracks and lanes: a before-after study. In: Proceedings of the Transportation Research Board Conference.

³² Planning, Alta, "Design (2009) Cycle Tracks Lessons Learned," (2009).

³³ Monsere, C. M., McNeil, N. and Dill, J. "Multiuser Perspectives on Separated, On-Street Bicycle Infrastructure," *Transportation Research Record: Journal of the Transportation Research Board* 2314 (2013): 22-30.

³⁴ Lusk, A. C., Furth, P. G., Morency, P., Miranda-Moreno, L. F., Willett, W. C. and Dennerlein, J. T., "Risk of injury for bicycling on cycle tracks versus in the street," *Injury Prevention* 17, no. 2 (2011): 131-135.

installed.³⁵ The experiences in Amsterdam and Copenhagen indicate that "two-way cycle tracks require a higher level of control at intersections to allow for a variety of turning movements. These movements should be guided by a separated signal for bicycles and for motor vehicles." Additionally, it is suggested that it would be better to put a two-way cycle on the side of a street where more destinations are located in order to prevent additional crossings.³⁶

2.6 RESEARCH QUESTIONS

Since most previous studies on bicycle infrastructures were undertaken at the level of jurisdiction and analyzed using correlation models, these model outputs identify patterns, but do not provide insights into the processes that create these patterns, including individual traffic user behaviors. This paper's focus is an empirical study of the performance of two cycle tracks in West Campus in Austin, Texas. The main research question in this study is that: How do cycle tracks affect all types of traffic users' behaviors and perspectives? This main question will be answered through specifically asking:

- What are the cyclists' behaviors and their interactions with pedestrians and motorists on cycle tracks?
- What are the perceptions of all types of traffic users (including bicyclists, pedestrians and motorists) regarding safety, comfort and operations?

³⁵ District of Department of Transportation, "Bicycle Facility Evaluation, Washington, DC," (2012).

³⁶ Planning, Alta, "Design (2009) Cycle Tracks Lessons Learned," (2009).

Chapter III: *Methods*

3.1 SETTINGS

This study was conducted in West Campus in Austin, Texas. West Campus is framed on the east by a major commercial strip known as "The Drag" or Guadalupe St. and on the west by Shoal Creek and the park. Due to its close proximity to the University of Texas at Austin and downtown, West Campus has among the highest population densities in the City of Austin and a high use of bicycles for routine transportation. According to 2012 ACS 5-year census tract estimates, 5.5 percent of commuters in West Campus bike to work, compared with 1.5% in Austin.³⁷

3.2 LOCATIONS SELECTION

This paper studies two cycle tracks in West campus that are installed on the bike routes with high use rating.

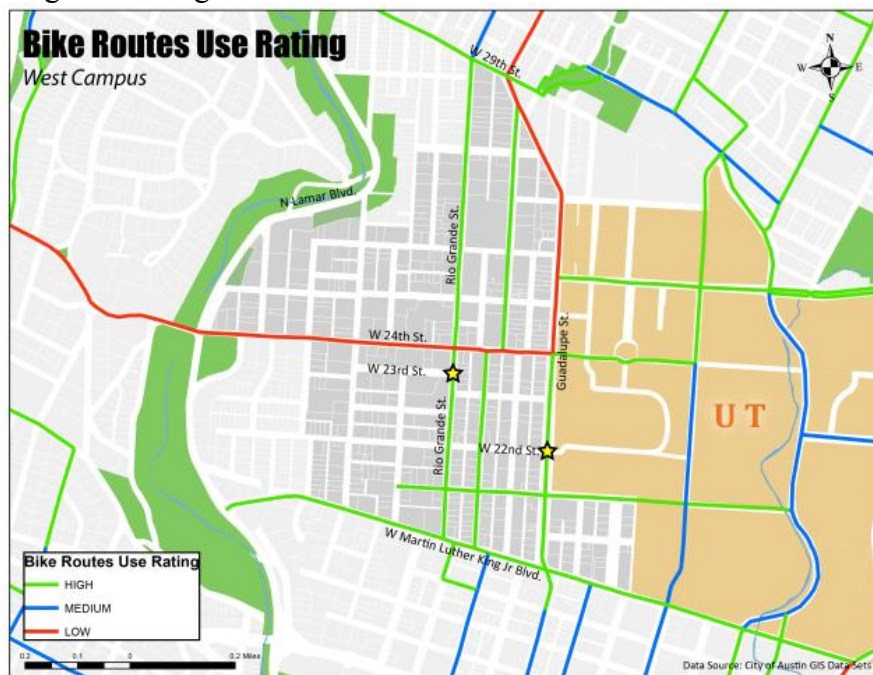


Figure 3.1: Bike Routes Use Rating in West Campus.

³⁷ 2012 ACS 5-year census tract estimates.

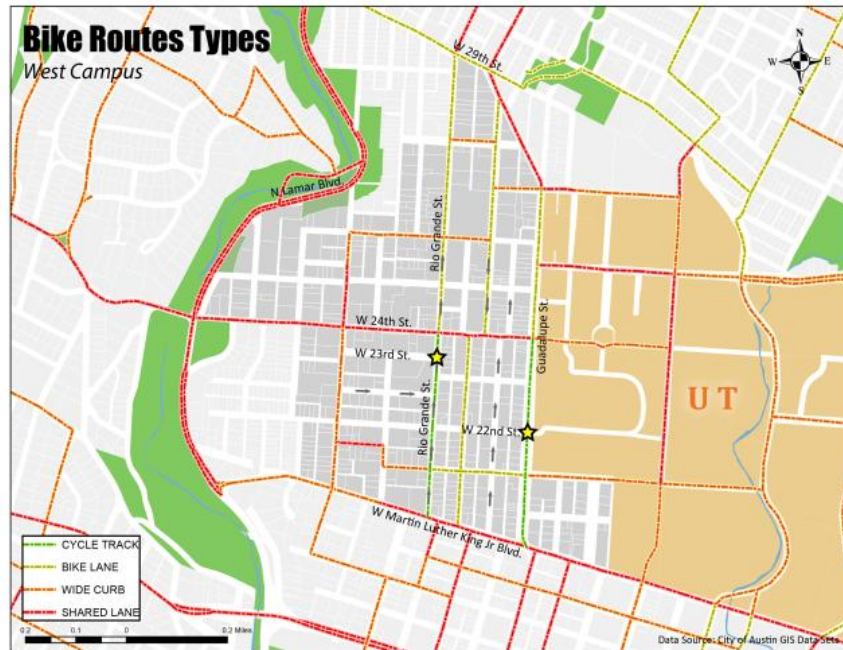


Figure 3.2: Bike Routes Types in West Campus.

3.2.1 Guadalupe St. from West 24th St. to Martin Luther King Jr. Blvd.: One-Way Cycle Track

Initiated by the 2010 Mobility Bond Guadalupe Improvement Project and Capital Metro’s MetroRapid Project, the 0.4-mile one-way cycle track on southbound Guadalupe St. was open to the public on October 17th, 2013. Guadalupe St. is a high-volume street connecting the old Highland Mall site (now becoming a major community college campus), the UT campus and downtown Austin. The cycle track is installed on one of the most congested parts of Guadalupe St. between W 24th St. and Martin Luther King Jr. Blvd. This section features a mix of motorized and non-motorized traffic, a combination of high traffic volume, and busy intersections during the peak hours. The purpose of building a cycle track is to "make bicycling along Guadalupe more comfortable for people of all ages and abilities, and provide the adjacent neighborhoods with easy bicycle access to the University of Texas, businesses on the Drag, and public transit," as stated by

Nathan Wilkes, City of Austin Bicycle Program. The cycle track is painted green and is separated from vehicle traffic by bus stops, including a MetroRapid bus stop, parked cars and street-level pedestrian islands.

3.2.2 Rio Grande St. from West 24th St. to Martin Luther King Jr. Blvd.: Two-Way Cycle Track

The 0.8-mile two-way cycle track along the west side of Rio Grande St. stretching from W 24th St. to Martin Luther King Jr. Blvd. is Austin's first Green Lane Project cycle track, unveiled in West Campus on April 23rd, 2012. The section of Rio Grande St. in West Campus features a one-way northbound street, low speed limit and high pedestrian volume. The cycle track starts with a bicycle signal to transition from the two-way facility to a more traditional street environment south of the traffic signal. It has two lanes, one for southbound bicyclists and the other for those going north. The cycle track is separated from the shared road by a four-foot painted buffer and flexible plastic delineators. Besides plenty of road markings, the pathway also features green-colored sections of street where driveways enter Rio Grande Street, alerting motorists that cyclists may be crossing.

3.3 DATA COLLECTION

For each cycle track, data collection included a 4-hour observation and 35 intercept surveys.

3.3.1 Multi-Modal Behavior Observation

The objective of observation was to empirically quantify all road users' behavior and their interactions with others in cycle tracks. Based upon previous studies and an on-site visit, a Cycle Track Multi-Modal Behavior form was prepared in advance (see Appendix A). Observation was conducted at the intersection of Guadalupe St. and W

22nd St. facing north and the intersection of Rio Grande St. and W 23rd St. facing south respectively from January 15th to March 18th. At each location, counting was conducted for a total of four hours, including two morning peak hours (8:30 a.m. to 10:00 a.m.) and two evening peak hours (4:30 p.m. to 6:00 p.m.). As cycling is an activity greatly influenced by weather conditions, data were collected when weather condition were fine with an ambient temperature of more than 5°C, few clouds and no precipitation.

Guadalupe One-Way Cycle Track			Rio Grande Two-Way Cycle Track		
Date	Morning Peak Hours 8:30 to 10:00	Evening Peak Hours 16:30 to 18:00	Date	Morning Peak Hours 8:30 to 10:00	Evening Peak Hours 16:30 to 18:00
Jan 15, Wed	8:30-9:00	16:30-17:00	Feb 27, Thu	9:00-9:30	16:30-17:00
Jan 16, Thu	9:00-9:30	16:45-17:15	Feb 28, Fri	9:15-9:45	17:15-17:45
Jan 21, Tue	9:00-9:30	16:30-17:00	Mar 6, Thu	9:00-9:30	16:45-17:15
Jan 22, Wed	9:45-10:15	16:30-17:00	Mar 18, Tue	9:15-9:45	17:15-17:45
Total	2 Hours	2 Hours	Total	2 Hours	2 Hours

Table 3.1: Observation Data Collection Summary.

3.3.2 Intercept Survey

In order to know all types of traffic users' experiences, perceptions and attitudes toward cycle tracks, on-site intercept surveys were administered to cyclists, pedestrians and motorists on Guadalupe St. and Rio Grande St. respectively from January to March. At each location, 35 surveys were collected, including 15 cyclist surveys, 10 pedestrian surveys and 10 motorist surveys. Cyclists were intercepted when they were using bicycle parking facilities. Pedestrians were intercepted on the sidewalks adjacent to cycle tracks. Motorists were approached near on-street parking or by asking pedestrians if they drove on Guadalupe/Rio Grande St., and if so, to participate by filling out a motorist survey. A major component of each survey involved asking respondents to indicate their level of agreement with a series of statements pertaining to their experiences and opinions on a

scale from 1 (strongly disagree) to 5 (strongly agree). The intercept surveys are presented in Appendix B to G.

3.4 DATA ANALYSIS

The observation data was first categorized according to the themes developed on the "Cycle Track Multi-Modal Behavior Form" (see Appendix A). Then, the frequencies of different types of behaviors under each category were divided into two sets of peaking hours and arranged in a table. Finally, the percentages were calculated for each category.

The data from the surveys was analyzed in two ways. First, a table of percentages for each level of agreement was calculated based on the frequencies, which displayed the distribution of levels of agreement towards one statement. Secondly, the mean of the scores was calculated as the average to show the overall agreement towards one statement. It was also used as an indicator to compare the level of agreement towards different statements.

3.5 LIMITATIONS

This study employed the combination of direct observation and intercept surveys so as to avoid many of the biases associated with self-reported behaviors or stated preferences, but the methods had some limitations.

The sample of observation was drawn from an accessible population rather than the target population and the sample size was very small. It is risky to generalize the research results from the accessible population to the target population. Thus, the external validity of this study is low, which means the findings of this study can only be used for the cycle tracks in West Campus. Meanwhile, the sample sizes in this study are not large enough to conduct comprehensive methodological testing and manipulate cause-and-effect variables such as in a casual research study, so the internal validity of this study is

low as well. However, this research does contribute to an exploratory analysis of a new form of infrastructure, and can provide insights into defining future research questions.

This evaluation addressed the "perceived safety" by road users rather the "real safety", such as number of crashes, mainly because of the infrequency of bicycle crashes and the short-time frame for the evaluation. Other factors that affected the reliability of this study included the small sample size of surveys for each type of road user and the lower temperatures of the dates when observation was conducted compared with the annual average temperature in Austin.

Comparing the average levels of agreement toward different statements is difficult if the statements refer to the problems under different categories. Sometimes, it is also hard to tell if an average score is "good" or "bad." In addition, if the numbers are not reliable, the analysis would not be particularly useful. Thus, this study looked at the observation and survey data in conjunction in order to form a sensible conclusion.

Chapter IV: *Data Analysis & Results*

4.1 EVALUATION OF ONE-WAY CYCLE TRACK ON GUADALUPE ST.

4.1.1 Observation Analysis

a. Cyclist Counts

Table 4.1 shows the number of morning and evening peak hour cyclists counted at the intersection of Guadalupe St. and W 22nd St. from January 15th to 22nd. The cyclist counts included all cyclists traveling along southbound Guadalupe St. inside or outside the cycle track. Counts average between 35 and 45 cyclists per hour. There were slightly more cyclists during the evening peak than the morning peak. Out of the 321 observed cyclists, only 49 (15%) were female.

Data	Morning Peak Hours 8:30 to 10:00		Evening Peak Hours 16:30 to 18:00	
	Time	Cyclist Counts	Time	Cyclist Counts
Jan 15, Wed	8:30-9:00	35	16:30-17:00	39
Jan 16, Thu	9:00-9:30	42	16:45-17:15	52
Jan 21, Tue	9:00-9:30	32	16:30-17:00	50
Jan 22, Wed	9:45-10:15	32	16:30-17:00	39
Total		141		180
			Total	321

Table 4.1: Cycling Traffic Volume on Southbound Guadalupe St.

b. Usage Rate

Table 4.2 shows the morning and evening peak hour usage rate of the cycle track, sidewalk and vehicle lane by cyclists on southbound Guadalupe St. respectively. Of the total 321 observed cyclists, 82% were riding in the cycle track, including 12% going the wrong way; 17% were riding on the adjacent sidewalk; and only 2% were riding on vehicle lanes. In most cases, sidewalk riding occurred when cyclists had a very short trip (not more than one-block distance) on Guadalupe St. or when they encountered large-

volume pedestrians standing or walking in the cycle track at the mid-block intersection between W 22nd St. and W 23rd St. In addition, 20% of cyclists rode the wrong way on Southbound Guadalupe St, which happened more often on the sidewalk than in the cycle track.

		Cycle Track		Sidewalk		Vehicle Lanes	Total
		South	North	South	North		
Morning Peak Hours	Counts	103	11	9	16	2	141
	Percent	73%	8%	6%	11%	1%	100%
Evening Peak Hours	Counts	121	26	14	15	4	180
	Percent	67%	14%	8%	8%	2%	100%
Total	Counts	224	37	23	31	6	321
	Percent	70%	12%	7%	10%	2%	100%

Table 4.2: Usage Rate of Cycle Track, Sidewalk and Vehicle Lane by Cyclists on Southbound Guadalupe St.

c. Encroachment

The number of observed non-cyclist users of the cycle track during the morning and evening peak hours are summarized in the Table 4.3. Pedestrians blocking the cycle track was the most common infraction with over 366 instances during 4 hours of observation, including 172 (47%) walking, 143 (39%) jaywalking, and the remaining 51 (14%) standing waiting for green lights. Most infraction occurred near the mid-block intersection between W 22nd St. and W 23rd St. In addition, 13 skateboarders and 1 motorcycle were observed encroaching on the cycle track. The number of encroachments during the morning peak hours was only around half of that during the evening peak hours. This might be explained by the smaller pedestrian volume during the morning peak compared with that of evening peak.

	Morning Peak Hours		Evening Peak Hours		Total	
	Count	Percent	Count	Percent	Count	Percent
Pedestrian	140	97%	226	96%	366	96%
Walking	70	50%	102	45%	172	47%
Jaywalking	50	36%	93	41%	143	39%
Standing	20	14%	31	14%	51	14%
Skateboard	3	2%	10	4%	13	3%
Motorcycle	1	1%	0	0%	1	0%
Total	144	100%	236	100%	380	100%

Table 4.3: Encroachments in the Cycle Track on Southbound Guadalupe St.

d. Signal Compliance

For cycle track riders arriving at the intersection of Guadalupe St. and W 22nd street and the mid-block intersection between W 22nd St. and W 23rd St. on red lights, signal compliance was recorded as shown in Table 4.4. Both intersections have high crossing volumes during the peak hours as they connect to the two main entrances on the west side of the UT campus. For the mid-block intersection, a new Yield to Pedestrians Sign was added with the installation of cycle track.

Overall, around 15% of the observed cyclists encountered red lights at the two intersections. Out of 34 cyclists who encountered red lights at the mid-block intersection, 14 cyclists (41%) opted to cross the pedestrian traffic or ride on the sidewalk. Compared with the mid-block intersection, the W 22nd St. intersection experienced fewer violations by cyclists (31%).

		Encountering Red Lights	Compliance	Violation
Mid-block Intersection	Count	34	20	14
	Percent	15%	59%	41%
W 22nd St. Intersection	Count	32	22	10
	Percent	14%	69%	31%

Table 4.4: Cyclist Signal Compliance and Violations at the Intersections Observed.

e. Cyclist Collisions and Near-Collisions

During the 4-hour period, 16 near-collisions were observed. Near-collisions were recorded when a cyclist or motor vehicle was forced to make an emergency change of direction or emergency change of speed in order to avoid a collision. 13 near-conflicts between bicyclists and pedestrians were observed, most of which occurred close to the intersections when pedestrians darted out in the cycle track on red lights. 2 near-conflicts between cyclists and vehicles were observed at the W 22nd St. intersection including one cyclist making an emergency change of direction to avoid a collision with a motor vehicle stuck in the cycle track waiting for green lights and another cyclist making an abrupt stop to avoid a motor vehicle making a right turn illegally. Only 1 near-conflict between two bicyclists occurred when one of them rode the wrong way in the cycle track. No fatal collisions happened during the observation.

4.1.2 Cyclist Survey Analysis

a. Respondents' Characteristics

Table 4.5 presents the demographics of the 15 respondents for the cyclist intercept survey. Twelve out of 15 respondents are between 20 and 30 years old and they are approximately evenly distributed by gender.

	Female	Male	Total
20-24	3	5	8
25-29	3	1	4
30-35	1	2	3
Total	7	7	14

Table 4.5: Age and Gender Distribution of Cyclist Survey on Guadalupe St.

The survey also asked respondents to report how often they rode bicycles on Guadalupe St. before and after the installation of cycle track. As shown in Figure 4.1, most respondents have rich cycling experiences on Guadalupe St. during both periods. Almost all respondents rode bicycles on Guadalupe St. for commuting.

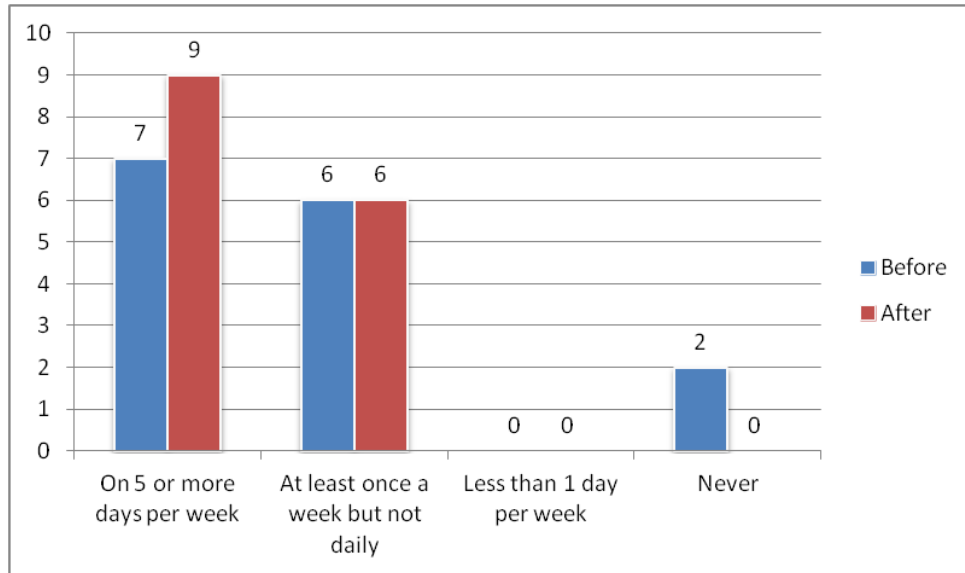


Figure 4.1: Self-Reported Frequency of Cycling on Guadalupe St. before and after the Cycle Track Installation.

b. Understanding and Compliance

Table 4.6 shows the self-reported understanding and compliance of the new cycle track markings and signals on Guadalupe St. Sixty-seven percent of respondents indicated that they understand the purpose of the new bicycle markings and signals and 73% said they would follow the marking and signals as intended.

	Strongly Disagree (1)	Disagree (2)	No Opinion (3)	Agree (4)	Strongly Agree (5)	% Agree	Mean
As a cyclist, I understand the purpose of the new bicycle markings and signals.	0%	7%	27%	27%	40%	67%	4.0
When cycling in the Cycle Track, I follow the markings and signals as intended.	0%	7%	20%	40%	33%	73%	4.0

Table 4.6: Self-Reported Understanding and Compliance by Cyclists on Guadalupe St.

c. Perception of Safety and Ease

Overall, respondents indicated that they feel safer and more at ease cycling on Guadalupe St. with the cycle track, as shown in Table 4.7. Among all respondents (15), there was a high level of agreement on the statement that the cycle track makes riding on Guadalupe St. safer (87%), less stressful (80%), easier (80%), and more convenient (93%). Additionally, 86% of respondents indicated that the cycle track has also made cycling through the intersection safer and 94% felt that the cycle track is wide enough. When cyclists were asked to compare pedestrians' encroachment before and after the cycle track installment, however, only 53% indicated that they encounter fewer pedestrians now than before. Additionally, 54% of respondents are still worried about being "doored" on cycle track.

	Strongly Disagree (1)	Disagree (2)	No Opinion (3)	Agree (4)	Strongly Agree (5)	% Agree	Mean
Cycle Track has made this section of street SAFER for me as a cyclist.	7%	0%	7%	27%	60%	87%	4.3
Cycle Track has made this section of street LESS STRESSFUL for me as a cyclist.	7%	7%	7%	20%	60%	80%	4.2
Cycle Track has made this section of street EASIER for me as a cyclist.	7%	7%	7%	20%	60%	80%	4.2
Cycle Track has made this section of street MORE CONVENIENT for me as a cyclist.	0%	7%	0%	33%	60%	93%	4.5
Cycle Track has made cycling through the intersection SAFER for me as a cyclist.	7%	0%	7%	33%	53%	86%	4.3
I feel that Cycle Track is wide enough.	0%	7%	0%	27%	67%	94%	4.5
When cycling through this section of street, I encounter FEWER pedestrians now than before the Cycle Track was installed.	7%	20%	20%	40%	13%	53%	3.3
While riding in the Cycle Track, I have to pay a lot of attention to avoid being "doored".	0%	20%	27%	7%	47%	54%	3.8

Table 4.7: Sense of Safety and Ease of Riding on Guadalupe St.

d. Collisions, Near-Collisions & Potential Conflicts

Table 4.8 provides the self-reported collisions and near-collisions with various road users or other objects in the cycle track on Guadalupe St. The definition of near-collision depends on respondents' self-interpretation and can include a wide range of interactions. Of 15 respondents, around 2 respondents indicated that they had been involved in collisions with a pedestrian, another bicyclist, and a turning motor vehicle

respectively, while over half of respondents indicated that they had experienced near-collisions with pedestrians, 6 with other cyclists, 5 with a turning motor vehicle, and 2 with a parking motor vehicle.

	Collision	Near-Collision	Total
A pedestrian	2	9	11
Another bicyclist	3	6	9
A turning motor vehicle	2	5	7
A parking motor vehicle	0	2	2
A Non-Moving Object	0	0	0
Something Else	0	0	0

Table 4.8: Self-Reported Collisions and Near-Collisions on Guadalupe St.

Cyclists were also asked to indicate the frequency of encountering potential conflicts when they ride in the cycle track. As shown in Table 4.9, of the scenarios posed, cyclists most commonly encountered pedestrians walking and standing in the cycle track waiting for green lights, followed by cyclists riding the wrong way and the motor vehicles encroaching on intersections.

	Never	Rarely	On Most Trips	On Almost Every Trip
Pedestrians walking in the Cycle Track;	0%	33%	60%	7%
Pedestrians waiting to across the Guadalupe standing in the Cycle Track than on the sidewalks or median island;	0%	33%	53%	13%
Cyclists riding on an opposite direction in the Cycle Track;	27%	33%	33%	7%
People skateboarding in the Cycle Track;	33%	53%	7%	7%
Motor vehicles driving in the Cycle Track;	73%	20%	7%	0%
Motor Vehicles waiting in the Cycle Track to make right/left turns.	27%	27%	40%	7%

Table 4.9: Self-Reported Frequency of Cycle Track Encounters on Guadalupe St.

e. Attitude and Recommendations

Overall, respondents indicated a positive attitude towards the cycle track on Guadalupe St. as shown in Table 4.10. Ninety-three percent agreed that cycle track makes for a better cycling environment in West Campus/Austin and 87% supported the cycle track. Two respondents also suggested that a cycle track should be implemented in all of the major commute routes leading from all points in Austin to the UT campus. On the other hand, the installation of the cycle track does not show a significant impact on ridership increase. Sixty-seven percent reported that they choose to cycle more often now than before the installation of cycle track and only 33% saw more people riding bicycles on Guadalupe St. Moreover, one respondent indicated that the design of the cycle track was not well thought-out and another respondent indicated that the right-of-way in the cycle track was not quite clear between pedestrians and cyclists.

	Strongly Disagree (1)	Disagree (2)	No Opinion (3)	Agree (4)	Strongly Agree (5)	% Agree	Mean
Cycle Track makes for a better cycling environment in West Campus/Austin.	7%	0%	0%	33%	60%	93%	4.4
I support the Cycle Track.	7%	0%	7%	27%	60%	87%	4.3
Since the Cycle Track was installed, I choose to cycle on street MORE often.	0%	13%	20%	20%	47%	67%	4.0
I see MORE people riding bicycles on Guadalupe since the Cycle Track was installed	0%	20%	47%	27%	7%	33%	3.2

Table 4.10: Cyclists Attitude towards the Cycle Track on Guadalupe St.

4.1.3 Pedestrian Survey Analysis

a. Respondents' Characteristics

The respondents for pedestrian survey on Guadalupe St. is evenly distributed by gender and age as shown in Table 4.11.

	Female	Male	Total
19-24	3	2	5
25-29	3	2	5
Total	6	4	10

Table 4.11: Age and Gender Distribution of Pedestrian Survey on Guadalupe St.

b. Understanding and Compliance

Respondents were asked to point out the place where pedestrians should wait to cross Guadalupe St. on red lights. Only 3 respondents had a wrong opinion that pedestrians could wait in the cycle track, while the remaining 7 respondents identified the right area, which is on the sidewalk or on the pedestrian median.

c. Collisions and Near-Collisions

Respondents were asked whether they been in involved in or witnessed a collision or near-miss collision with cyclists in the cycle track while crossing Guadalupe St. The definition of near-collision depends on respondents' self-interpretation and can include a wide range of interactions. Overall, 4 out of 10 respondents indicated that they have witnessed a near-collision between pedestrians and bicyclists and one of them has been involved in a near-collision with pedestrians as well.

d. Perceptions on Pedestrians Environment

Respondents were asked 3 questions in order to understand general opinions about the pedestrian environment adjacent to the installed cycle track. Responses, as

shown in Table 4.12, indicate that most pedestrians do not feel a change or improvement of the walking environment on Guadalupe St. Seven out of 10 respondents disagreed with or were not sure about the statement that fewer bicyclists are riding on the sidewalk after the installation of the cycle track. Over half of the respondents do not feel that the installation of the cycle track have improved the experience of walking or crossing Guadalupe St. Nonetheless, 7 out of 10 respondents still indicated their support for the cycle track on Guadalupe St.

	Strongly Disagree (1)	Disagree (2)	No Opinion (3)	Agree (4)	Strongly Agree (5)	% Agree	Mean
I see FEWER people riding bicycles on sidewalk since the Cycle Track was installed	0%	30%	40%	20%	10%	30%	3.1
The Cycle Track makes for a BETTER environment for pedestrians WALKING on the sidewalk next to the cycle track.	0%	10%	50%	30%	10%	40%	3.4
The Cycle Track makes for a BETTER environment for pedestrians CROSSING Guadalupe.	0%	10%	50%	30%	10%	40%	3.4
I support the Cycle Track.	0	0%	30%	40%	30%	70%	4.0

Table 4.12: Perceptions on Pedestrians Environment on Guadalupe St.

4.1.4 Motorist Survey Analysis

a. Respondents' Characteristics

Table 4.13 shows the demographics of 10 respondents for the motorist survey. 8 out of 10 respondents are over 25 years old and they are approximately evenly distributed by gender.

	Female	Male	Total
20-24	1	1	2
25-29	1	3	4
>= 30	2	2	4
Total	4	6	10

Table 4.12: Age and Gender Distribution of Motorist Survey on Guadalupe St.

b. Experience with Cycle Track

As seen in Table 4.13, respondents opinions on the impact of the cycle track have had on driving through Guadalupe St. were generally positive or neutral. 60% indicated that fewer cyclists were riding in the car lanes since the cycle track was installed, while 70% and 50% indicated that the cycle track had made driving on Guadalupe St safer and more convenient respectively. Few respondents indicated that the cycle track was responsible for increased traffic congestion (40%) or increased challenges when parking (30%). However, it is noticed that only 30% of respondents indicated that intersection signals, signs, and street markings denote clear right-of-way. No collisions or near-collisions were reported by respondents. Overall, 9 out of 10 respondents support the installation of the cycle track.

	Strongly Disagree (1)	Disagree (2)	No Opinion (3)	Agree (4)	Strongly Agree (5)	% Agree	Mean
There are FEWER cyclists riding in the car lanes since the cycle track was installed.	10%	0%	20%	50%	20%	60%	3.7
The traffic congestion has gotten WORSE since the Cycle Track was installed.	0%	0%	60%	30%	10%	40%	3.5
Intersection signals, signs, and street markings make it CLEAR who has the right-of-way (bike or cars) at intersections on Guadalupe.	0%	10%	50%	30%	10%	40%	3.4
Parking is MORE STRESSFUL & CHALLENGING, since the cycle track was installed.	0%	40%	30%	20%	10%	30%	2.9
Cycle Track has made driving on Guadalupe SAFER.	0%	10%	20%	50%	20%	70%	3.8
Cycle Track has made driving on Guadalupe MORE CONVENIENT.	0%	20%	30%	40%	10%	50%	3.4
Overall, I LIKE that bicycles are separated from the motor vehicle traffic	0%	0%	10%	60%	30%	90%	4.2

Table 4.13: Motorist Experience with Cycle Track on Guadalupe St.

4.1.5 Main Findings

(1) Sidewalk riding still happens after the installation of cycle track. During the 4-hour period, 17% of cyclists were observed riding on sidewalks instead of the cycle track, most of which happened when cyclists had a short trip on Guadalupe St. or when the cycle track was fully encroached by pedestrians. The issue is also confirmed in pedestrian surveys in which 7 out of 10 respondents indicated that they do not experience fewer cyclists on sidewalks after the installation of the cycle track and half of them indicated that the cycle track does not significantly improve the pedestrian environment on Guadalupe St.

(2) *The encroachment by pedestrians poses a safety risk to both bicyclists and pedestrians.* Pedestrian encroachment on Guadalupe cycle track is rampant, with 389 occurrences recorded during four-hour observation. The observation result is also consistent with the cyclist survey responses. Over half of the cyclists indicated that the occurrence of encountering pedestrians walking or standing in the cycle track happened on most trips. Only 53% of cyclists indicated that they encounter fewer pedestrians now than before the cycle track was installed. Additionally, 13 near-collisions between bicyclists and pedestrians were observed during the four-hour period and 5 out of 10 cyclists and pedestrians reported that they have witnessed or been involved in a near-collision between pedestrians and bicyclists.

(3) *The safety of intersections is a big concern for all road users.* Out of 16 observed near-collisions between cyclists and pedestrians/turning vehicles on Guadalupe cycle track, 15 happened adjacent to or in intersections. There are also 7 collisions/near-collisions between cyclists and turning vehicles reported by respondents. Additionally, the observation analysis also reveals a high traffic violation rate by both cyclists and pedestrians. An average of 36% of cyclists arriving at red lights violated the signal. The violation rate is especially high at the mid-block intersection between 22nd St. and 23rd St. Only 6 out of 10 cyclists would stop and yield to the pedestrians walking at the signaled crosswalk, while a large number of pedestrians were observed jaywalking and standing in the cycle track. In addition, over half of the pedestrians and motorists indicated that signals, signs, and street markings do not make it clear who has the right-of-way at intersections.

(4) *Perceptions of the cycle track's safety are generally positive among both cyclists and motorists.* Although many unsafe interactions with pedestrians were observed, over 80% of cyclists reported agreement on the statement that the protected

bicycle lanes increases the safety and ease of riding bicycles on Guadalupe St. Motorists did not indicate that the cycle track caused any problems in terms of increased congestion or parking challenges, while 70% indicated that fewer cyclists ride in the vehicle lanes after the installation of cycle track , which makes driving through Guadalupe St. safer than before.

(5) *Almost all road users support the installment of the cycle track on Guadalupe St.* Cyclists indicated that the cycle track makes for a better cycling environment in West Campus and nearly 9 out of 10 road users responding to surveys indicated their support for the installation of the cycle track on Guadalupe St. Moreover, some respondents recommended that cycle tracks should be implemented on all of the major commute routes leading from all points in Austin to the UT campus.

4.2 EVALUATION OF TWO-WAY CYCLE TRACK ON RIO GRANDE ST.

4.2.1 Observation Analysis

a. Cyclist Counts

Table 4.14 shows the number of morning and evening peak hour cyclists counted at the intersection of Rio Grande St. and W 23rd St. from February 27th to March 18th. The cyclist counts included all cyclists traveling along Rio Grande St. inside or outside the cycle track. Counts average between 30 and 40 cyclists per hour. More cyclists were observed during the evening peak than during the morning peak. Out of the 282 cyclists observed, 73 (35%) were female, which is 20% higher than Guadalupe St.

	Morning Peak Hours 8:30 to 10:00		Evening Peak Hours 16:30 to 18:00	
Data	Time	Cyclist Counts	Time	Cyclist Counts
Feb 27, Thu	9:00-9:30	37	16:30-17:00	52
Feb 28, Fri	9:15-9:45	28	17:15-17:45	41
Mar 6, Thu	9:00-9:30	31	16:45-17:15	32
Mar 18, Tue	9:15-9:45	28	17:15-17:45	33
Total		124		158
			Total	282

Table 4.14: Cycling Traffic Volume on Rio Grande St.

b. Usage Rate

Table 4.15 shows the morning and evening peak hour usage rate of the cycle track, sidewalk and vehicle lane by cyclists on southbound Rio Grande St. respectively. Of the total 282 observed cyclists, 91% were riding in the cycle track, including 33% in riding south and 58% riding north. There were many more cyclists riding north than those riding south, especially during the evening peak. Going each way, approximately 5% of cyclists cycled in the wrong direction, which usually happened when cyclists were going to turn left at the closest intersection or when there were more than 2 cyclists riding the

same way. Besides, 2% and 7% of cyclists were observed riding on the sidewalk and in vehicle lanes respectively. Most of them had a very short trip on Rio Grande St.

		Cycle Track		Sidewalk	Vehicle Lanes	Total
		South	North			
Morning Peak Hours	Counts	45	65	2	12	124
	Percent	36%	52%	2%	10%	100%
Evening Peak Hours	Counts	47	99	3	9	158
	Percent	30%	62%	2%	6%	100%
Total	Counts	92	164	5	21	282
	Percent	33%	58%	2%	7%	100%

Table 4.15: Usage Rate of Cycle Track, Sidewalk and Vehicle Lane by Cyclists on Rio Grande St.

c. Encroachment

The number of observed non-cyclist users of the cycle track during the morning and evening peak hours are summarized in the Table 4.16. The problem of pedestrian encroachment in the cycle track was serious on Rio Grande St. with over 518 instances during 4 hours of observation, including 58 (11%) walking or jogging and 458 (83%) jaywalking. The number of jaywalkers was especially high on the section of Rio Grande St. between W 22nd St. and W 24th St. The intersections on this section have no signal control and poor connectivity. W 23rd St. is divided into two unconnected sectors by Rio Grande St. and the W 22 1/2 St. is standing between W 22nd and W 23rd St. on the west side of Rio Grande St. Although there is a crosswalk connecting the east side of W 23rd St. to the west side of Rio Grande St., it is seldom used by the students who walking from W 22 1/2 St. or the other side of W 23rd St. (Figure 4.2)

It is worth mentioning that 16 observed motor vehicles encroached the cycle track on Grande St. during the 4-hour observation, including 5 parked vehicles (2 delivery

truck, 2 from property maintenance company, and 1 private car) and 11 vehicles driving to/from the parking lot located on the west side of Rio Grande St. between W 23rd St. and W 22 1/2 St. (Figure 4.2) In addition, there were another 14 people skateboarding in the cycle track.

	Count	Percent
Pedestrian	516	94%
Walking	58	11%
Jaywalking	458	83%
Skateboard	14	3%
Motor Vehicle	16	3%
Total	546	100%

Table 4.16: Encroachments in the Cycle Track on Rio Grande St.

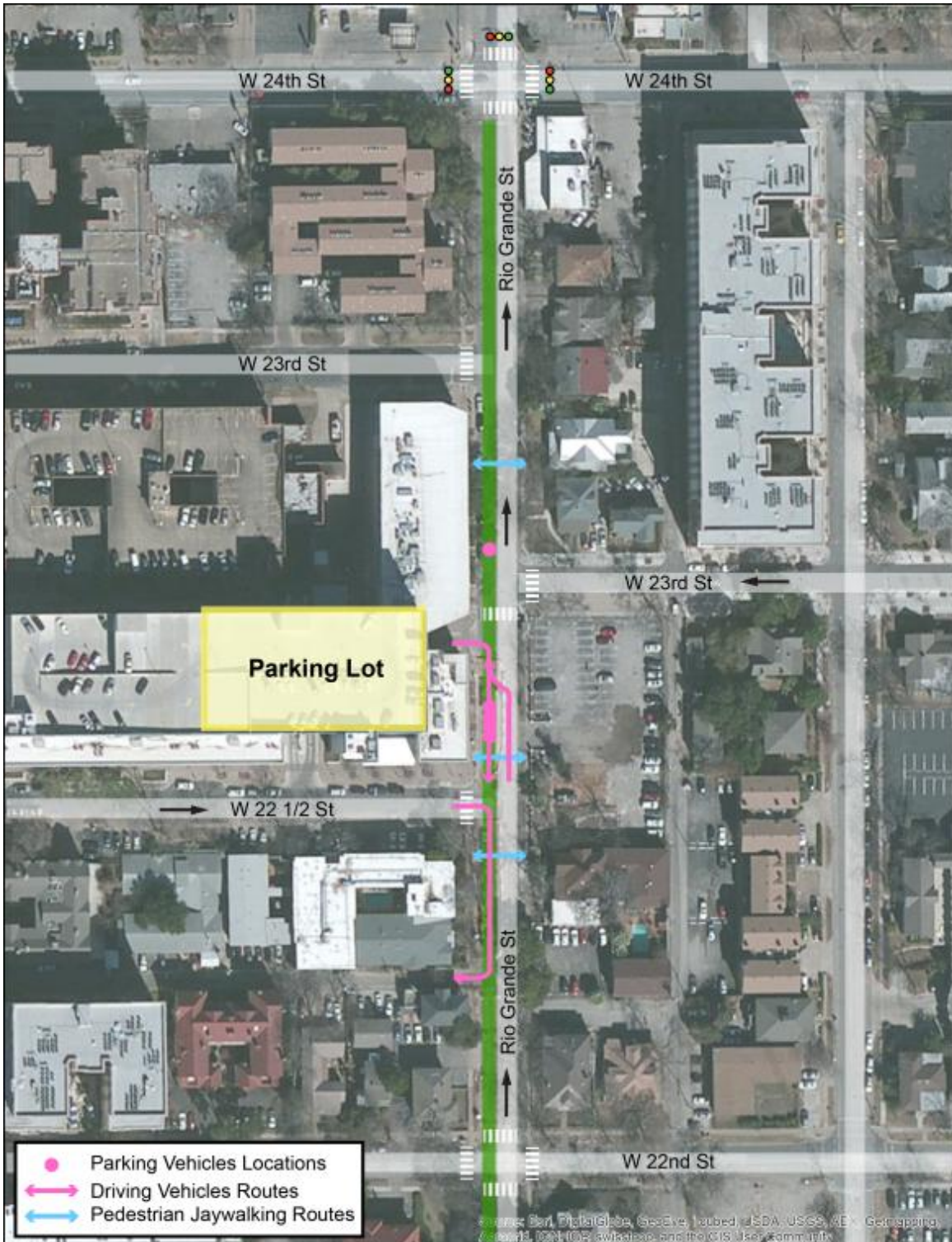


Figure 4.2: Pedestrian and Vehicle Encroachments in the Cycle Track on Rio Grande St.

d. Cyclist Collisions and Near-Collisions

During the 4 hours of observation, 2 near-collisions were observed, including one bicyclist forced to make an emergency stop to avoid two jaywalking pedestrians in the middle of the block between W 22 1/2 St. and W 22nd St. and another bicyclist making a sudden change of the direction to avoid a driving vehicle encroaching the cycle track near the parking lot. No fatal collisions happened during the observation period.

4.2.2 Cyclist Survey Analysis

a. Respondents' Characteristics

Table 4.17 presents the demographics of 15 respondents to the cyclist survey. 11 out of 15 respondents are between 19 and 30 years old and they are approximately evenly distributed by gender.

	Female	Male	Total
19-24	3	4	7
25-30	2	2	4
> 30	1	3	4
Total	6	9	15

Table 4.17: Age and Gender Distribution of Cyclist Survey on Rio Grande St.

The survey also asked respondents to report their frequency of riding bicycles in the cycle track on Rio Grande St. As shown in Figure 4.3, most respondents rode on Rio Grande St. at least once a week. Almost all respondents rode bicycles on Rio Grande St. for commuting.

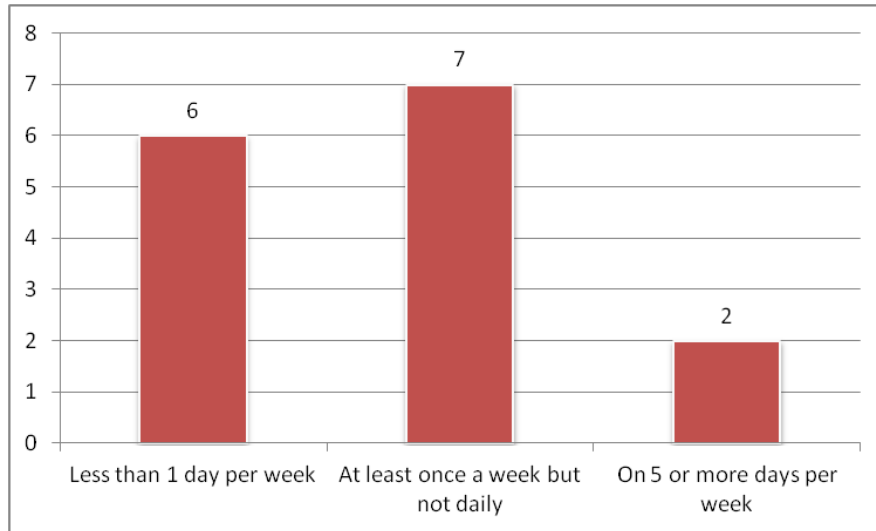


Figure 4.3: Self-Reported Frequency of Cycling in the Cycle Track on Rio Grande St.

b. Understanding and Compliance

Table 4.18 shows the self-reported understanding and compliance of the new cycle track markings and signals on Guadalupe St. Overall, 73% of respondents indicated that they understand the purpose of the new bicycle markings and signals, and that they would follow the marking and signals as intended as well.

	Strongly Disagree (1)	Disagree (2)	No Opinion (3)	Agree (4)	Strongly Agree (5)	% Agree	Mean
As a cyclist, I understand the purpose of the new bicycle markings and signals.	13%	7%	7%	40%	33%	73%	3.7
When cycling in the Cycle Track, I follow the markings and signals as intended.	0%	7%	20%	33%	40%	73%	4.1

Table 4.18: Self-Reported Understanding and Compliance by Cyclists on Rio Grande St.

c. Perception of Safety and Ease

Overall, respondents indicated that they feel safer and more at ease cycling on Rio Grande St. with the cycle track, as shown in Table 4.19. Among all respondents (15),

there was a high level of agreement on the statement that the cycle track makes riding on Rio Grande St. safer (93%), less stressful (100%), easier (93%), and more convenient (73%). Additionally, 73% of respondents felt that the cycle track is wide enough. However, the opinions on the intersections safety were mixed. Only 60% agreed with the statement that the cycle track has made cycling through intersections safer. Moreover, when asked cyclists to compare pedestrians' encroachment on the Rio Grande cycle track with other streets in West Campus, less than half of the respondents indicated that they encounter fewer pedestrians.

	Strongly Disagree (1)	Disagree (2)	No Opinion (3)	Agree (4)	Strongly Agree (5)	% Agree	Mean
Cycle Track has made cycling through the intersection SAFER for me as a cyclist.	7%	13%	20%	27%	33%	60%	3.7
Cycle Track has made cycling on Rio Grande SAFER for me as a cyclist.	0%	0%	7%	53%	40%	93%	4.3
Cycle Track has made Rio Grande LESS STRESSFUL for me as a cyclist.	0%	0%	0%	67%	33%	100%	4.3
Cycle Track has made Rio Grande EASIER for me as a cyclist.	0%	0%	7%	53%	40%	93%	4.3
Cycle Track has made Rio Grande MORE CONVENIENT for me as a cyclist.	0%	13%	13%	53%	20%	73%	3.8
I feel that Cycle Track is wide enough.	7%	0%	20%	27%	47%	73%	4.1
When cycling through Rio Grande Cycle Track, I encounter FEWER pedestrians than other streets in West Campus.	20%	13%	20%	27%	20%	47%	3.1

Table 4.19: Sense of Safety and Ease of Riding on Rio Grande St.

d. Collisions, Near-Collisions & Potential Conflicts

Table 4.20 provides the self-reported collisions and near-collisions with various road users or other objects in the cycle track on Rio Grande St. Of 15 respondents, 5 respondents indicated that they had been involved in a collision/near-collision with a pedestrian, and 3 respondents had been involved in a near-collision with a turning vehicle at one of the intersections on Rio Grande St.

	Collision	Near-Collision	Total
A pedestrian	1	4	5
Another bicyclist	0	0	0
A turning motor vehicle	0	3	3
A parking motor vehicle	0	0	0
A Non-Moving Object	0	0	0
Something Else	0	0	0

Table 4.20: Self-Reported Collisions and Near-Collisions on Rio Grande St.

Cyclists were also asked to indicate the frequency of encountering potential conflicts when they ride in the cycle track. As shown in Table 4.21, of the scenarios posed, cyclists most commonly encountered pedestrians crossing the Cycle Track without using the crosswalk, followed by pedestrians walking and people skateboarding in the cycle track.

	Never	Rarely	On Most Trips	On Almost Every Trip
Pedestrians walking in the Cycle Track;	13%	53%	33%	0%
Pedestrians crossing the Cycle Track without using the crosswalk	7%	13%	47%	33%
Cyclists riding the wrong way in the Cycle Track;	27%	67%	7%	0%
People skateboarding in the Cycle Track;	13%	47%	40%	0%
Motor vehicles driving in the Cycle Track;	47%	53%	0%	0%
Motor Vehicles parking in the Cycle Track.	40%	47%	13%	0%

Table 4.21: Self-Reported Frequency of Cycle Track Encounters on Rio Grande St.

e. Attitude and Recommendations

Overall, respondents indicated a positive attitude towards the cycle track on Rio Grande St. as shown in Table 4.22. Eighty-seven percent agreed that the cycle track makes for a better cycling environment in West Campus/Austin, 73% indicated that the cycle track is working well, and 93% supported the cycle track. On the other hand, the installation of the cycle track does not show a significant impact on ridership increase. Only 57% of the respondents reported that they choose to cycle more often now than before the installation of the cycle track. Additionally, two respondents also looked forward to the cycle track extension north of W 24th St. to at least W 29st St. One respondent said, "Lack of connectivity of the bike lanes increases the inconvenience for bikers."

	Strongly Disagree (1)	Disagree (2)	No Opinion (3)	Agree (4)	Strongly Agree (5)	% Agree	Mean
Cycle Track makes for a better cycling environment in West Campus/Austin.	0%	0%	13%	20%	67%	87%	4.5
I think the Cycle Track is working well.	0%	7%	20%	27%	47%	73%	4.1
I support the Cycle Track.	0%	0%	7%	27%	67%	93%	4.6
Since the Cycle Track was installed, I choose to cycle on street MORE often.	0%	20%	27%	33%	20%	53%	3.5

Table 4.22: Cyclists Attitude towards the Cycle Track on Rio Grande St.

4.2.3 Pedestrian Survey Analysis

a. Respondents' Characteristics

Most respondents for pedestrian survey on Rio Grande St. is between 18 and 24 years old and they are approximately evenly distributed by gender as shown in Table 4.23.

	Female	Male	Total
18-24	4	3	7
> 25	1	2	3
Total	5	5	10

Table 4.23: Age and Gender Distribution of Pedestrian Survey on Rio Grande St.

b. Collisions and Near-Collisions

Respondents were asked whether they have been involved in or witnessed a collision or near-miss collision with cyclists on Rio Grande St. along the cycle track. The definition of near-collision depends on respondents' self-interpretation and can include a wide range of interactions. Overall, 2 out of 10 respondents indicated that they have

witnessed and been involved in a near-collision between pedestrians and bicyclists in the Rio Grande cycle track.

c. Perceptions on Pedestrians Environment

Respondents were asked 3 questions in order to understand general opinions on the pedestrian environment adjacent to the installed cycle track. Responses, as shown in Table 4.24, indicate that most pedestrians feel that there has been an improvement to the walking environment along the cycle track thanks to the decrease in sidewalk riding. However, 7 out of 10 respondents disagreed with or were not sure about the statement that the cycle track makes for a better environment for pedestrians crossing Rio Grande St. Overall, there is high support for cycle tracks among the respondents.

	Strongly Disagree (1)	Disagree (2)	No Opinion (3)	Agree (4)	Strongly Agree (5)	% Agree	Mean
I often see people riding bicycles on the sidewalk nearby the cycle track	0%	60%	20%	10%	10%	20%	2.7
The Cycle Track makes for a <i>BETTER</i> environment for pedestrians <i>WALKING</i> on the sidewalk next to the cycle track.	0%	10%	30%	60%	0%	60%	3.5
The Cycle Track makes for a <i>BETTER</i> environment for pedestrians <i>CROSSING</i> Rio Grande.	0%	10%	60%	30%	0%	30%	3.2
I support the Cycle Track.	0	10%	20%	60%	10%	70%	3.7

Table 4.24: Perceptions on Pedestrians Environment on Rio Grande St.

4.2.4 Motorist Survey Analysis

a. Respondents' Characteristics

Table 4.25 shows the demographics of the 10 respondents to the motorist survey. Seven out of 10 respondents are between 20 and 30 years old and they are approximately evenly distributed by gender.

	Female	Male	Total
20-24	3	2	5
25-29	0	2	2
>= 30	1	2	3
Total	4	6	10

Table 4.25: Age and Gender Distribution of Motorist Survey on Rio Grande St.

b. Experience with Cycle Track

According to the responses, as shown in Table 4.26, to the motorist survey, although most respondents agreed that driving on Rio Grande St. is safer than before, the installation of the cycle track raises some other issues. Around half of respondents indicate that the cycle track was responsible for increased traffic congestion (50%) or increased parking related difficulties (50%). One respondent made a comment that, "The installation of cycle track is a waste of road space," and another respondent thought that the bike lanes should flow in the same direction as traffic. Only 20% of respondents agreed that intersection signals, signs, and street markings make it clear who has the right-of-way at intersections on Rio Grande. There were also two self-reported near-collisions between bicyclists and motorists at the W 22nd St intersection and Martin Luther King Jr. Blvd. intersection. 40% of respondents indicated that the cycle track has made driving on Rio Grande St. less convenient. Nevertheless, all respondents indicated support for the separation of bike lanes from vehicle lanes.

	Strongly Disagree (1)	Disagree (2)	No Opinion (3)	Agree (4)	Strongly Agree (5)	% Agree	Mean
There are FEWER cyclists riding in the car lanes since the cycle track was installed.	10%	10%	40%	30%	10%	40%	3.2
The traffic congestion has gotten WORSE since the Cycle Track was installed.	10%	0%	40%	20%	30%	50%	3.6
Intersection signals, signs, and street markings make it CLEAR who has the right-of-way (bike or cars) at intersections on Rio Grande.	10%	40%	30%	20%	0%	20%	2.6
Parking is MORE STRESSFUL & CHALLENGING, since the cycle track was installed.	0%	0%	50%	30%	20%	50%	3.7
Cycle Track has made driving on Rio Grande SAFER.	10%	0%	10%	50%	30%	80%	3.9
Cycle Track has made driving on Rio Grande MORE CONVENIENT.	20%	20%	30%	20%	10%	30%	2.8
Overall, I LIKE that bicycles are separated from the motor vehicle traffic	0%	0%	0%	30%	70%	100%	4.7

Table 4.26: Motorist Experience with Cycle Track on Rio Grande St.

4.2.5 Main Findings

(1) *Jaywalking pedestrians constitute a viable threat to the safety of cyclists riding in the two-way cycle track on Rio Grande St.* This section of street is located in a high-density neighborhood but with no signal control at intersections and poor connectivity between the east and west side of the street, which increases the likelihood of jaywalking on Rio Grande St. Eighty percent of cyclists indicated that it is common to encounter jaywalking pedestrians on most trips in the cycle track. 5 out of 15 cyclists reported that they had been involved in a collision/near-collision with a pedestrian in the

cycle track. Moreover, pedestrians also indicated the need for pedestrian crossing improvements on Rio Grande St.

(2) *Vehicle encroachment is uncommon in the two-way cycle track on Rio Grande St., but when it happens, the whole track will be blocked.* Sixteen motor vehicles were observed driving on the cycle track for parking and a short cut close to the parking lot located on the west side of Rio Grande St. between W 23rd St. and W 22 1/2 St. during the 4-hour observation. Broken Bollards need to be fixed at specific intervals to prevent encroachments.

(3) *Cyclists overwhelmingly indicated that riding in the two-way cycle track on Rio Grande St. is safer, less stressful and easier,* in spite of the potential safety risk caused by the large number of pedestrians encroaching the cycle track. Additionally, 73% of respondents felt that the cycle track is wide enough.

(4) *Pedestrians reported that there are fewer cyclists riding on sidewalks now.* Thanks to the decrease in sidewalk riding, most pedestrians feel that the walking environment has improved after the installation of the two-way cycle track.

(5) *Motorists generally agreed that the two-way cycle track makes driving on Rio Grande St. safer, but have some other concerns.* Around half of the motorists found that traffic congestion has gotten worse and they have fewer options for parking after the installation of the two-way cycle track. Half of the motorists indicated that intersection signals, signs, and street markings do not make it clear who has the right-of-way at intersections on Rio Grande St. The existing design for the intersections is also a safety concern for most cyclists. 3 out of 15 cyclists reported that they had been involved in a near-collision with a turning vehicle at one of the intersections on Rio Grande St.

(6) *The two-way cycle track on Rio Grande St. has popular support among all types of road users.* Eighty-seven percent of cyclists agreed cycle tracks make for a better

cycling environment in West Campus/Austin. Almost all road users indicated their support for the installation of the two-way cycle track on Rio Grande St. Some cyclists also look forward to the extension of the cycle track north to W 29th St. and south to downtown area.

Chapter V: *Conclusion*

This paper evaluated the performance of two types of cycle tracks—the one-way cycle track on Guadalupe St. and the two-way cycle track on Rio Grande St.—in West Campus in Austin, Texas, through observing various road users' behaviors and assessing their perceptions on safety, comfort and operation. These evaluations are important for understanding how cycle tracks, as a form of infrastructure, affect the experience of the various traffic users. Overall, the findings in this study indicate that while cycle tracks improve the sense of safety and comfort for cyclists, but, at the same time, other people—including pedestrians—misuse the space, resulting in potential safety issues with the existing intersection design that might undermine overall success.

A total of 603 cyclists were observed riding bicycles on Guadalupe St. and Rio Grande St. during the 4-hour period, of which 86% were riding on cycle tracks, 9% were riding on the sidewalks, and 4% were still riding on the vehicle lanes. Although more cyclists were observed riding bicycles on Guadalupe St. than Rio Grande St., the usage rate of the cycle track on Guadalupe St was 10% lower than that of Rio Grande St. mainly due to the higher percentage of sidewalk riding on Guadalupe St. There are no data available to compare the amount of sidewalk riding before and after the cycle track installation on each street, but, according to the pedestrians surveys, 7 out of 10 respondents indicated that they do not encounter fewer cyclists on sidewalks after the installation of the cycle track on Guadalupe St, while the perceptions were reversed for Rio Grande St. The reason why the cycle track on Guadalupe St. does not have a significant impact on reducing sidewalk cycling might be that it is a one-way cycle track while the street is two-way. Moreover, the high pedestrian volume along the streets often block the cycle track during the peak hours, which makes some cyclists choose to ride on the sidewalks.

		Guadalupe St.	Rio Grande St.	Total
Total Cyclists	Counts	321	282	603
Cycle Track	Counts	261	256	517
	Percent	81%	91%	86%
Sidewalk	Counts	51	5	56
	Percent	16%	2%	9%
Vehicle Lane	Counts	6	21	27
	Percent	2%	7%	4%

Table 5.1: Usage Rate of Cycle Track, Sidewalk and Vehicle Lane by Cyclists on Guadalupe St. and Rio Grande St.

Most cyclists comply with the riding rules of the cycle tracks on both streets, with only 10% of cyclists riding the wrong way. However, the rate of signal compliance by cyclists at intersections, in particular the mid-block intersection between W 22nd St. and W 23rd St. on Guadalupe St., is low. Cyclists have a responsibility to yield to pedestrians at both signaled and unsignaled crosswalks, but the observation data show that 40% of cyclists chose to negotiate the pedestrians on red lights. On the other hand, the violation rate by pedestrians is also high. Pedestrians jaywalking, along with walking and jogging, were the most commonly occurring type of encroachment in cycle tracks on both streets. The frequency of encountering pedestrians during trips in cycle tracks was the highest according to the cyclists. Moreover, based on observation and surveys, the collisions and near-collisions in the cycle tracks most commonly happened between cyclists and pedestrians. The high violation rate by both cyclists and pedestrians indicates not only the need for education and enforcement campaigns to encourage compliance with traffic signals but also for the improved design to protect cyclists from pedestrians.

		Guadalupe St.	Rio Grande St.	Total
Total Encroachment	Counts	403	546	949
Pedestrian	Counts	389	516	905
	Percent	97%	95%	95%
Motor Vehicle	Counts	1	16	17
	Percent	0%	3%	2%
Skateboard	Counts	13	14	27
	Percent	3%	3%	3%

Table 5.2: Encroachment in Cycle Tracks on Guadalupe St. and Rio Grande St.

The cycle tracks in West Campus have the same intersection design issue as many previous studies indicated. Most of the observed and self-reported collisions and near-collisions happened close to or at the intersections. On Guadalupe St. the existing intersection design still uses the pedestrian signal to control cyclists’ movement, while on Rio Grande St. almost all intersections use stop signs to control the conflicting traffic movements. Around half of the respondents indicated that signals, signs and street markings do not make it clear who has the right of way at intersections. Additionally, the signal violation rate is high, especially by pedestrians, as mentioned above. Thus, intersection safety is big concern for all road users according to the surveys.

Perceptions of safety and the comfort of riding bicycles in cycle tracks are overwhelmingly positive among cyclists and the installation of cycle tracks in Austin receives high support from not only bicyclists but also pedestrians and motorists.

Overall, this study identifies the problems of encroachment, non-compliance with traffic rules, and intersection design as the potential risks that might affect cycling safety in cycle tracks. Future research is needed to quantify the drivers—such as the pedestrian volume, the number of intersections, the surrounding land use type, and the barrier design—of encroachment in cycle tracks; to examine the intersection design

improvement that would prevent bicyclists from fatal crashes in cycle tracks; and to identify additional factors that affects the usage rate and cycling safety in cycle tracks.

Appendix A: Cycle Track Multi-Modal Behavior Count Form

Location:	Start Time:
Count Date:	End Time:
Weather:	

I. Cyclists Count

Gender		Cycle Track		Sidewalk		Vehicle Lane	
Male	Female	North	South	North	South	North	South

II. Encroachment by Other Road Users

Pedestrians <u>Walking</u>	Pedestrians <u>Crossing</u>	Vehicle <u>Driving</u>	Vehicle <u>Parking</u>	Other Users

III. Intersection

Encounter Red Light	No Compliance

IV. Conflicts

Near Conflicts with <u>Pedestrians</u>	Near Conflicts with <u>Vehicles</u>	Near Conflicts with <u>Bicycles</u>	Near Conflicts with <u>Other Users</u>	Real Conflicts

Appendix B: Bicyclist Intercept Survey (Guadalupe St.)

Dear Bicyclist,

My name is Weijun Zhang. I am a graduate student in the Community & Regional Planning Program at UT. I am now conducting a study about the bicycle infrastructures evaluation in West Campus. I hope that the results will contribute to future plans for improving bicycling in Austin. Obtaining perceptions and attitudes from bicyclists, pedestrians and drivers is vital to this study. I would appreciate your taking the time to complete the following survey. It should take about 5 minutes of your time. Your answers will be completely anonymous. Thank you!

Time: _____ **Date:** _____ **Location:** Guadalupe @ 21st **Bicycle Infrastructure:** Cycle Track

1. Gender: Male Female **2. Age:** _____

3. What skill level do you consider yourself as a bicyclist?

Beginner/Novice Intermediate/Recreational Advanced/Serious

4. How often do you ride bicycle on Guadalupe *BEFORE* the installation of Cycle Track?

On 5 or more days per week At least once a week but not daily Less than 1 day per week Never

How often do you ride bicycle on Guadalupe *AFTER* the installation of Cycle Track?

On 5 or more days per week At least once a week but not daily Less than 1 day per week Never

5. For which purposes do you bike on Guadalupe?

6. Please indicate how often you have observed the following to happen on your trips on the Guadalupe Cycle Track:

	Never	Rarely	On Most Trips	On Almost Every Trip
Pedestrians walking in the Cycle Track;				
Pedestrians waiting to across the Guadalupe standing in the Cycle Track than on the sidewalks or median island;				
Cyclists riding on an opposite direction in the Cycle Track;				
People skateboarding in the Cycle Track;				
Motor vehicles driving in the Cycle Track;				
Motor Vehicles waiting in the Cycle Track to make right/left turns;				
Cars parked in the Cycle Track.				

9. Have you ever experienced a near-collision / collision with ... on Guadalupe Cycle Track? If Yes, please indicate the location. (Choose all that apply)

Near-Collision

A pedestrian Yes _____ No _____
 Another bicyclist Yes _____ No _____
 A turning motor vehicle Yes _____ No _____
 A parking motor vehicle Yes _____ No _____
 A Non-Moving Object Yes _____ No _____
 Something Else Yes _____ No _____

Collision

A pedestrian Yes _____ No _____
 Another bicyclist Yes _____ No _____
 A turning motor vehicle Yes _____ No _____
 A parking motor vehicle Yes _____ No _____
 A Non-Moving Object Yes _____ No _____
 Something Else Yes _____ No _____

10. Please choose the level of agreement towards the following statements:

As a cyclist, I understand the purpose of the new bicycle markings and signals.	Strongly Disagree	1	2	3	4	5	Strongly Agree
When cycling in the Cycle Track, I follow the markings and signals as intended.	Strongly Disagree	1	2	3	4	5	Strongly Agree
I feel that Cycle Track is wide enough.	Strongly Disagree	1	2	3	4	5	Strongly Agree
When cycling through Guadalupe, I encounter <i>FEWER</i> pedestrians now than before the Cycle Track was installed.	Strongly Disagree	1	2	3	4	5	Strongly Agree
While riding in the Cycle Track, I have to pay a lot of attention to avoid being "doored" (e.g., having a car door open into the pathway of the bicycle).	Strongly Disagree	1	2	3	4	5	Strongly Agree
Cycle Track has made cycling through the intersection <i>SAFER</i> for me as a cyclist.	Strongly Disagree	1	2	3	4	5	Strongly Agree
Cycle Track has made Guadalupe <i>SAFER</i> for me as a cyclist.	Strongly Disagree	1	2	3	4	5	Strongly Agree
Cycle Track has made Guadalupe <i>LESS STRESSFUL</i> for me as a cyclist.	Strongly Disagree	1	2	3	4	5	Strongly Agree
Cycle Track has made Guadalupe <i>EASIER</i> for me as a cyclist.	Strongly Disagree	1	2	3	4	5	Strongly Agree
Cycle Track has made Guadalupe <i>MORE CONVENIENT</i> for me as a cyclist.	Strongly Disagree	1	2	3	4	5	Strongly Agree
Since the Cycle Track was installed, I choose to cycle on street <i>MORE</i> often.	Strongly Disagree	1	2	3	4	5	Strongly Agree
I see <i>MORE</i> people riding bicycles on Guadalupe since the Cycle Track was installed	Strongly Disagree	1	2	3	4	5	Strongly Agree
Cycle Track makes for a better cycling environment in West Campus/Austin.	Strongly Disagree	1	2	3	4	5	Strongly Agree
I think the Cycle Track is working well.	Strongly Disagree	1	2	3	4	5	Strongly Agree
I support the Cycle Track.	Strongly Disagree	1	2	3	4	5	Strongly Agree

11. Please provide any additional comments you may have about Cycle Track on Guadalupe that have not been addressed.

Appendix C: Pedestrian Intercept Survey (Guadalupe St.)

Dear Pedestrian,

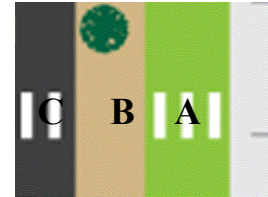
My name is Weijun Zhang. I am a graduate student in the Community & Regional Planning Program at UT. I am now conducting a study about the bicycle infrastructures evaluation in West Campus. I hope that the results will contribute to future plans for improving bicycling in Austin. Obtaining perceptions and attitudes from bicyclists, pedestrians and drivers is vital to this study. I would appreciate your taking the time to complete the following survey. It should take about 3 minutes of your time. Your answers will be completely anonymous. Thank you!

Time: _____ **Date:** _____ **Location:** Guadalupe @ 21st **Bicycle Infrastructure:** Cycle Track

1. Gender: Male Female **2. Age:** _____

3. When you have walked through the Guadalupe, did you see any signs about the cycle track?
 Yes No

**4. Where can pedestrians wait to cross Guadalupe when the pedestrian crossing signal is red?
 (Refer to the picture to the right)**



- A: On the sidewalk/curb
- B: In the cycle track
- C: On the pedestrian median

5. Have you been involved in or witnessed a collision or near-miss collision with a cyclist on Guadalupe along the cycle track? If Yes, please indicate the location. (Choose all that apply)

- Yes. I was involved in a collision with a cyclist. _____
- Yes. I was involved in a near-miss collision with a cyclist. _____
- Yes. I witnessed a cyclist/pedestrian collision. _____
- Yes. I witnessed a cyclist/pedestrian near-miss collision. _____
- No. I have not such experiences.

6. Please choose the level of agreement towards the following statements:

I see <i>FEWER</i> people riding bicycles on sidewalk since the Cycle Track was installed	Strongly Disagree	1	2	3	4	5	Strongly Agree
The Cycle Track makes for a <i>BETTER</i> environment for pedestrians <i>WALKING</i> on the sidewalk next to the cycle track.	Strongly Disagree	1	2	3	4	5	Strongly Agree
The Cycle Track makes for a <i>BETTER</i> environment for pedestrians <i>CROSSING</i> Guadalupe.	Strongly Disagree	1	2	3	4	5	Strongly Agree
I support the Cycle Track.	Strongly Disagree	1	2	3	4	5	Strongly Agree

7. Is there anything you think should be changed about the Cycle Track on Guadalupe?

- Yes No Don't know

If so, what should be changed about the Cycle Track?

Appendix D: Motorist Intercept Survey (Guadalupe St.)

Dear Driver,

My name is Weijun Zhang. I am a graduate student in the Community & Regional Planning Program at UT. I am now conducting a study about the bicycle infrastructures evaluation in West Campus. I hope that the results will contribute to future plans for improving bicycling in Austin. Obtaining perceptions and attitudes from bicyclists, pedestrians and drivers is vital to this study. I would appreciate your taking the time to complete the following survey. It should take about 3 minutes of your time. Your answers will be completely anonymous. Thank you!

Time: _____ **Date:** _____ **Location:** Guadalupe @ 21st **Bicycle Infrastructure:** Cycle Track

1. Gender: Male Female **2. Age:** _____

3. Please choose the level of agreement towards the following statements:

There are FEWER cyclists riding in the car lanes since the cycle track was installed.	Strongly Disagree	1	2	3	4	5	Strongly Agree
The traffic congestion has gotten WORSE since the Cycle Track was installed.	Strongly Disagree	1	2	3	4	5	Strongly Agree
Intersection signals, signs, and street markings make it CLEAR who has the right-of-way (bike or cars) at intersections on Guadalupe.	Strongly Disagree	1	2	3	4	5	Strongly Agree
Parking is MORE STRESSFUL & CHALLENGING, since the cycle track was installed.	Strongly Disagree	1	2	3	4	5	Strongly Agree
Cycle Track has made driving on Guadalupe SAFER.	Strongly Disagree	1	2	3	4	5	Strongly Agree
Cycle Track has made driving on Guadalupe MORE CONVENIENT.	Strongly Disagree	1	2	3	4	5	Strongly Agree
Motor vehicle driver's behavior on street is SAFER and CLAMER since Cycle Track was installed.	Strongly Disagree	1	2	3	4	5	Strongly Agree
Overall, I LIKE that bicycles are separated from the motor vehicle traffic	Strongly Disagree	1	2	3	4	5	Strongly Agree

4. Have you been involved in or witnessed a collision or near-miss collision with a cyclist at the intersections on Guadalupe since the cycle track was installed? (Choose all that apply)

- Yes. I was involved in a collision with a cyclist at the intersection between Guadalupe and _____
- Yes. I witnessed a cyclist/driver collision at the intersection between Guadalupe and _____
- No. I have not such experiences.

5. Is there anything you think should be changed about the Cycle Track on Guadalupe?

- Yes No Don't know

If yes, what should be changed about the Cycle Track?

Appendix E: Bicyclist Intercept Survey (Rio Grande St.)

Dear Bicyclist,

My name is Weijun Zhang. I am a graduate student in the Community & Regional Planning Program at UT. I am now conducting a study about the bicycle infrastructures evaluation in West Campus. I hope that the results will contribute to future plans for improving bicycling in Austin. Obtaining perceptions and attitudes from bicyclists, pedestrians and drivers is vital to this study. I would appreciate your taking the time to complete the following survey. It should take about 5 minutes of your time. Your answers will be completely anonymous. Thank you!

Time: _____ **Date:** _____ **Location:** Rio Grande **Bicycle Infrastructure:** Two-Way Cycle Track

1. Gender: Male Female **2. Age:** _____

3. What skill level do you consider yourself as a bicyclist?

Beginner/Novice Intermediate/Recreational Advanced/Serious

4. How often do you ride bicycle on Rio Grande?

On 5 or more days per week At least once a week but not daily Less than 1 day per week Never

5. For which purposes do you bike on Rio Grande?

6. Please indicate how often you have observed the following to happen on your trips on the Rio Grande Cycle Track:

	Never	Rarely	On Most Trips	On Almost Every Trip
Pedestrians walking in the Cycle Track;				
Pedestrians crossing the Cycle Track without using the crosswalk;				
Cyclists riding the wrong way in the Cycle Track;				
People skateboarding in the Cycle Track;				
Motor vehicles driving in the Cycle Track;				
Motor Vehicles parking in the Cycle Track;				

7. Have you ever experienced a near-collision / collision with ... on Rio Grande Cycle Track? If Yes, please indicate the location. (Choose all that apply)

Near-Collision

A pedestrian Yes _____ No
 Another bicyclist Yes _____ No
 A turning motor vehicle Yes _____ No
 A parking motor vehicle Yes _____ No
 A Non-Moving Object Yes _____ No
 Something Else Yes _____ No

Collision

A pedestrian Yes _____ No
 Another bicyclist Yes _____ No
 A turning motor vehicle Yes _____ No
 A parking motor vehicle Yes _____ No
 A Non-Moving Object Yes _____ No
 Something Else Yes _____ No

8. Please choose the level of agreement towards the following statements:

As a cyclist, I understand the purpose of the bicycle markings and signals.	Strongly Disagree	1	2	3	4	5	Strongly Agree
When cycling in the Cycle Track, I follow the markings and signals as intended.	Strongly Disagree	1	2	3	4	5	Strongly Agree

I feel that Cycle Track is wide enough.	Strongly Disagree	1	2	3	4	5	Strongly Agree
When cycling through Rio Grande, I encounter <i>FEWER</i> pedestrians than other streets in West Campus.	Strongly Disagree	1	2	3	4	5	Strongly Agree
Cycle Track has made cycling through the intersection <i>SAFER</i> for me as a cyclist.	Strongly Disagree	1	2	3	4	5	Strongly Agree
Cycle Track has made cycling on Rio Grande <i>SAFER</i> for me as a cyclist.	Strongly Disagree	1	2	3	4	5	Strongly Agree
Cycle Track has made Rio Grande <i>LESS STRESSFUL</i> for me as a cyclist.	Strongly Disagree	1	2	3	4	5	Strongly Agree
Cycle Track has made Rio Grande <i>EASIER</i> for me as a cyclist.	Strongly Disagree	1	2	3	4	5	Strongly Agree
Cycle Track has made Rio Grande <i>MORE CONVENIENT</i> for me as a cyclist.	Strongly Disagree	1	2	3	4	5	Strongly Agree
Since the Cycle Track was installed, I choose to cycle on street <i>MORE</i> often.	Strongly Disagree	1	2	3	4	5	Strongly Agree
Cycle Track makes for a better cycling environment in West Campus/Austin.	Strongly Disagree	1	2	3	4	5	Strongly Agree
I think the Cycle Track is working well.	Strongly Disagree	1	2	3	4	5	Strongly Agree
I support the Cycle Track.	Strongly Disagree	1	2	3	4	5	Strongly Agree

9. Please provide any additional comments you may have about Cycle Track on Rio Grande that have not been addressed.

Appendix F: Pedestrian Intercept Survey (Rio Grande St.)

Dear Pedestrian,

My name is Weijun Zhang. I am a graduate student in the Community & Regional Planning Program at UT. I am now conducting a study about the bicycle infrastructures evaluation in West Campus. I hope that the results will contribute to future plans for improving bicycling in Austin. Obtaining perceptions and attitudes from bicyclists, pedestrians and drivers is vital to this study. I would appreciate your taking the time to complete the following survey. It should take about 3 minutes of your time. Your answers will be completely anonymous. Thank you!

Time: _____ **Date:** _____ **Location:** Rio Grande **Bicycle Infrastructure:** Two-Way Cycle Track

1. Gender: Male Female **2. Age:** _____

3. Have you been involved in or witnessed a collision or near-miss collision with a cyclist on Rio Grande along the cycle track? If Yes, please indicate the location. (Choose all that apply)

- Yes. I was involved in a collision with a cyclist. _____
- Yes. I was involved in a near-miss collision with a cyclist. _____
- Yes. I witnessed a cyclist/pedestrian collision. _____
- Yes. I witnessed a cyclist/pedestrian near-miss collision. _____
- No. I have not such experiences.

4. Please choose the level of agreement towards the following statements:

I often see people riding bicycles on sidewalk nearby the cycle track	Strongly Disagree	1	2	3	4	5	Strongly Agree
The Cycle Track makes for a <i>BETTER</i> environment for pedestrians <i>WALKING</i> on the sidewalk next to the cycle track.	Strongly Disagree	1	2	3	4	5	Strongly Agree
The Cycle Track makes for a <i>BETTER</i> environment for pedestrians <i>CROSSING</i> Rio Grande.	Strongly Disagree	1	2	3	4	5	Strongly Agree
I support the two-way cycle track on Rio Grande.	Strongly Disagree	1	2	3	4	5	Strongly Agree

5. Is there anything you think should be changed about the Cycle Track on Rio Grande?

- Yes No Don't know

If so, what should be changed about the Cycle Track?

Appendix G: Motorist Intercept Survey (Rio Grande St.)

Dear Driver,

My name is Weijun Zhang. I am a graduate student in the Community & Regional Planning Program at UT. I am now conducting a study about the bicycle infrastructures evaluation in West Campus. I hope that the results will contribute to future plans for improving bicycling in Austin. Obtaining perceptions and attitudes from bicyclists, pedestrians and drivers is vital to this study. I would appreciate your taking the time to complete the following survey. It should take about 3 minutes of your time. Your answers will be completely anonymous. Thank you!

Time: _____ **Date:** _____ **Location:** Rio Grande St. **Bicycle Infrastructure:** Two-Way Cycle Track

1. Gender: Male Female **2. Age:** _____

3. Please choose the level of agreement towards the following statements:

There are FEWER cyclists riding in the car lanes since the cycle track was installed.	Strongly Disagree	1	2	3	4	5	Strongly Agree
The traffic congestion has gotten WORSE since the Cycle Track was installed.	Strongly Disagree	1	2	3	4	5	Strongly Agree
Intersection signals, signs, and street markings make it CLEAR who has the right-of-way (bike or cars) at intersections on Rio Grande.	Strongly Disagree	1	2	3	4	5	Strongly Agree
Parking is MORE STRESSFUL & CHALLENGING, since the cycle track was installed.	Strongly Disagree	1	2	3	4	5	Strongly Agree
Cycle Track has made driving on Rio Grande SAFER.	Strongly Disagree	1	2	3	4	5	Strongly Agree
Cycle Track has made driving on Rio Grande MORE CONVENIENT.	Strongly Disagree	1	2	3	4	5	Strongly Agree
Overall, I LIKE that bicycles are separated from the motor vehicle traffic	Strongly Disagree	1	2	3	4	5	Strongly Agree

4. Have you been in involved in or witnessed a collision or near-miss collision with a cyclist on Rio Grande since the cycle track was installed? (Choose all that apply. If Yes, please indicate the location.)

- Yes. I was involved in a collision with a cyclist. _____
- Yes. I witnessed a cyclist/driver collision. _____
- No. I have not such experiences.

5. Is there anything you think should be changed about the Cycle Track on Rio Grande?

- Yes No Don't know

If yes, what should be changed about the Cycle Track?

Bibliography

- Akar, G. and Clifton, K. J., "Influence of individual perceptions and bicycle infrastructure on decision to bike," *Transportation Research Record: Journal of the Transportation Research Board* 2140, no. 1 (2009): 165-172.
- Balsas, C. JL. "Sustainable transportation planning on college campuses," *Transport Policy* 10, no. 1 (2003): 35-49.
- Black, W. R., "Sustainable transportation: a US perspective," *Journal of Transport Geography* 4 (1996): 151-159.
- Brown-West, O. G., "Optimization model for parking in the campus environment," *Transportation Research Record: Journal of the Transportation Research Board* 1564, no. 1 (1996): 46-53.
- Bustillos, B. I., Shelton, J. and Chiu, Y., "Urban university campus transportation and parking planning through a dynamic traffic simulation and assignment approach," *Transportation Planning and Technology* 34, no. 2 (2011): 177-197.
- "Changing Lanes: Austin's Cycle Tracks," BIKEAUSTIN, accessed Dec 8, 2013, <http://bikeaustin.org/education/changing-lanes-austins-cycle-tracks/>.
- "Changing Lanes," BIKEAUSTIN, accessed Dec 8, 2013, <http://bikeaustin.org/wp-content/uploads/2013/09/Bike-Austin-Cycle-Tracks-Changing-Lanes-brochure-2013-10.pdf>.
- Chen, L. et al. "Evaluating the Safety Effects of Bicycle Lanes in New York City," *American Journal of Public Health* 102, no.6 (2012): 1120-1127.
- Dill, J. and Carr, T., "Bicycle commuting and facilities in major US cities: if you build them, commuters will use them," *Transportation Research Record: Journal of the Transportation Research Board* 1828, no. 1 (2003): 116-123.
- District of Department of Transportation, "Bicycle Facility Evaluation, Washington, DC," (2012).
- Garrard, J., Rose, G., and Lo, S.K. "Promoting transportation cycling for women: The role of bicycle infrastructure," *Preventive Medicine* 46, no.1 (2008): 55-59.
- "Green Lane Project," peopleforbikes, accessed Mar 16, 2014, <http://www.peopleforbikes.org/green-lane-project/pages/about-the-project>.
- Herrstedt, L., *Planning and safety of bicycles in urban area*, No. VTI konferens 9A part 3, 1998.
- Jensen, Søren Underlien, Claus Rosenkilde, and Niels Jensen. "Road safety and perceived risk of cycle facilities in Copenhagen." Presentation to AGM of European Cyclists Federation (2007).

- Jensen, Søren Underlien., "Bicycle tracks and lanes: A before-after study," In 87th Annual Meeting of the Transportation Research Board. Transportation Research Board, Washington, DC. 2008.
- Larsen, J. and El-Geneidy, A., "A travel behavior analysis of urban cycling facilities in Montréal, Canada," *Transportation research part D: transport and environment* 16, no. 2 (2011): 172-177.
- Lusk, A. C., Furth, P. G., Morency, P., Miranda-Moreno, L. F., Willett, W. C. and Dennerlein, J. T., "Risk of injury for bicycling on cycle tracks versus in the street," *Injury Prevention* 17, no. 2 (2011): 131-135.
- Massink, R., Zuidgeest, M., Rijnsburger, J., Sarmiento, O. L. and van Maarseveen, M. "The Climate Value of Cycling," *Natural Resources Forum* 35 (2011): 100-111.
- Miller, J. D., and Handy, S. L., "Factors That Influence University Employees to Commute by Bicycle," *Transportation Research Record: Journal of the Transportation Research Board* 2314, no. 1 (2012): 112-119.
- Monsere, C. M., McNeil, N. and Dill, J. "Multiuser Perspectives on Separated, On-Street Bicycle Infrastructure," *Transportation Research Record: Journal of the Transportation Research Board* 2314 (2013): 22-30.
- Nelson, A. C., and Allen, D., "If you build them, commuters will use them: association between bicycle facilities and bicycle commuting," *Transportation Research Record: Journal of the Transportation Research Board* 1578, no. 1 (1997): 79-83.
- New York City Departments of Health and Mental Hygiene, Parks and Recreation, Transportation, and the New York City Police Department, "Bicyclist Fatalities and Serious Injuries in New York City (1996-2005)," accessed Mar 19th, 2014, <http://www.nyc.gov/html/dot/downloads/pdf/bicyclerfatalities.pdf>.
- Planning, Alta, "Design (2009) Cycle Tracks Lessons Learned," (2009).
- Pucher, J., Komanoff, C. and Schimek, P. "Bicycling Renaissance in North America? Recent Trends and Alternative Policies to Promote Bicycling," *Transportation Research Part A: Policy and Practice* 33 (1999): 625-654.
- Reynolds, C. C., Harris, A. M., Teschke, K., Cripton, P. A. and Winters, M., "The impact of transportation infrastructure on bicycling injuries and crashes: a review of the literature." *Environmental Health* 8, no. 1 (2009): 47.
- Schimek, P., "Cycle Track Safety Remains Unproven," *American Journal of Public Health* 103, no.10 (2013): e6-e7.
- Teschke, K., et al., "Route infrastructure and the risk of injuries to bicyclists: A case-crossover study," *American journal of public health* 102, no. 12 (2012): 2336-2343.

- The City of New York, "Prospect Park West Bicycle Path and Traffic Calming," accessed Mar 19th, 2014, <http://www.nyc.gov/html/dot/html/bicyclists/prospectparkwest.shtml>.
- Von Huth SL, Borch-Johnsen K and Jørgensen T, "Commuting physical activity is favorably associated with biological risk factors for cardiovascular disease," *Eur J Epidemiol* 22 (2007): 771-779.
- Wagner A, Simon C, Ducimetiere P, Montaye M, Bongrad V, Yarnell J, Bingham A, Hedelin G, Amouyel P and Ferrieres J, "Leisure-time physical activity and regular walking or cycling to work are associated with adiposity and 5y weight gain in middle-aged men: the PRIME study," *Int J Obes* 25 (2001): 940-948.
- Whannell, P., Whannell, R. and White, R., "Tertiary student attitudes to bicycle commuting in a regional Australian university," *International Journal of Sustainability in Higher Education* 13, no. 1 (2012): 34-45.
- Willis, D. P., Manaugh, K. and El-Geneidy, A., "Cycling under Influence: Summarizing the influence of attitudes, habits, social environments and perceptions on cycling for transportation." In *92nd Transportation Research Board Annual Meeting, Washington DC, USA*. 2013.