SAFETY AND USER PERCEPTIONS OF AUXILIARY BIKE LANES

Final Report

SPR 869

RESEARCH

Oregon Department of Transportation

SAFETY AND USER PERCEPTIONS OF AUXILIARY BIKE LANES

Final Report

SPR 869

by

David Hurwitz, Ph.D., Professor
Hisham Jashami, Ph.D, Assistant Professor (Sr Res)
Helena Breuer, M.S., Graduate Research Assistant
Oregon State University

for

Oregon Department of Transportation
Research Section
555 13th Street NE, Suite 1
Salem OR 97301

and

Federal Highway Administration
1200 New Jersey Avenue SE
Washington, DC 20590

April 2024

Technical Report Documentation Page

1. Report No. FHWA-OR-RD-24-08	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle SAFETY AND USER PERCEPTIONS OF AUXILIARY BIKE LANES		5. Report Date April 2024 6. Performing Organization Code
7. Author(s) David Hurwitz, Hisham Jashami, Helena Breuer		8. Performing Organization Report No.
9. Performing Organization Name and Address Oregon Department of Transportation Research Section 555 13th Street NE, Suite 1 Salem, OR 97301		10. Work Unit No. (TRAIS) 11. Contract or Grant No.
12. Sponsoring Agency Name and Address Oregon Dept. of Transportation Research Section 555 13th Street NE, Suite 1 Salem, OR 97301	Federal Highway Admin. 1200 New Jersey Avenue SE Washington, DC 20590	13. Type of Report and Period Covered Final Report 14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

This research studied Oregon drivers' and cyclists' conceivability of and receptivity to bike turnouts (auxiliary bike lanes). The driver and cyclist survey consisted of 32 and 35 questions, respectively, all of which were fixed choice, except for 3 open-ended response questions. The surveys were distributed online to 612 Oregon residents, made up of 305 licensed drivers and 307 active cyclists. The results from both surveys revealed overwhelming receptivity to implementing bike turnouts in Oregon. On average, the perceived potential impacts on safety and user comfort were reported to have the greatest degree of effectiveness. Further, these discrete findings were validated by drivers' and cyclists' open-ended responses following the formal education of bike turnouts. Collectively, these findings confirm the viability of bike turnouts as they are perceived to be an effective solution for curves on two-lane roads with limited visibility and constricted ROW.

17. Key Words	18. Distribution Statement
Bike Turnouts, Auxiliary Bike Lanes, Overtaking, Vehicle-Overtaking-Cyclist	Copies available from NTIS, and online at www.oregon.gov/ODOT/TD/TP_RES/

19. Security Classification (of this report)	20. Security Classification (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	143	

Technical Report Form DOT F 1700.7 (8-72) Reproduction of completed page authorized Printed on recycled paper

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	millimeters squared	mm^2
ft^2	square feet	0.093	meters squared	m^2
yd^2	square yards	0.836	meters squared	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	kilometers squared	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	ml
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	meters cubed	m^3
yd^3	cubic yards	0.765	meters cubed	m^3
~NOTE: Volumes greater than 1000 L shall be shown in m^3.				
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		TEMPERATURE (exact)		
°F	Fahrenheit	(F-32)/1.8	Celsius	°C

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	millimeters squared	0.0016	square inches	in^2
m^2	meters squared	10.764	square feet	ft^2
m^2	meters squared	1.196	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	kilometers squared	0.386	square miles	mi^2
		VOLUME		
ml	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	meters cubed	35.315	cubic feet	ft^3
m^3	meters cubed	1.308	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.102	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celsius	1.8C+32	Fahrenheit	°F

*SI is the symbol for the International System of Measurement

ACKNOWLEDGEMENTS

The authors thank the Oregon Department of Transportation (ODOT) and the Federal Highway Administration (FHWA) for funding this research. The Technical Advisory Committee Nick Fortey, (FHWA), Gary Obery (ODOT), Frank Belleque (ODOT), Roger Gutierrez (ODOT), Kevin Haas (ODOT), Daniel Serpico (ODOT) and Jiguang Zhao (ODOT), provided valuable input throughout the project. We would also like to thank OSU graduate students, Logan Scott-Deeter and Kezia Suwandhaputra for traveling with Lena to Mount Diablo State Park to record the ibn-survey videos. We would also like to thank undergraduate research assistants Matthew Prak and Emilio Calderon for serving as raters for 1,836 open-ended responses. The project was managed by ODOT Research Coordinators Josh Roll, Anthony Knudson, and Matt Bagwell.

DISCLAIMER

This document is disseminated under the sponsorship of the Oregon Department of Transportation and the United States Department of Transportation in the interest of information exchange. The State of Oregon and the United States Government assume no liability of its contents or use thereof.

The contents of this report reflect the view of the authors who are solely responsible for the facts and accuracy of the material presented. The contents do not necessarily reflect the official views of the Oregon Department of Transportation or the United States Department of Transportation.

The State of Oregon and the United States Government do not endorse products of manufacturers. Trademarks or manufacturers' names appear herein only because they are considered essential to the object of this document.

This report does not constitute a standard, specification, or regulation.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

On a road, absent a bike lane or sufficiently wide shoulder, a vehicle-overtaking-cyclist maneuver commonly involves a driver approaching a cyclist downstream and upon reaching the cyclist, entering the adjacent section of the roadway (median, adjacent lane, or opposing lane) to pass the cyclist, and then shifting back into the original through lane. Depending on the striping and conditions of the roadway, this may be considered illegal, and nonetheless, unsafe if performed incorrectly. On roadways that do not exhibit sufficient clearance or horizontal and vertical curves that impose restricted sight distance, this risk can be exacerbated. Under risky enough conditions, or when a person is driving conservatively, a queue of drivers may develop behind the climbing cyclist. If there is no feasible recovery area downstream for the cyclist or no section of roadway with safe passing conditions (e.g., a combination of sight distance, length of roadway, presence of opposing users), the queue of drivers grows at the rate of arrival. As time passes, this is interpreted as time lost to the queued drivers, and the perceived need to overtake the cyclist increases. Further, as the queue increases, the first driver may feel more pressure to overtake the cyclist. Ultimately, the cyclist's safety may be adversely affected by these confounding factors.

Many vehicle-overtaking-cyclist incidents at Mount Diablo State Park located in Northern California have followed similar patterns of events. This state park consists of two-lane roads with limited sight distance, and the absence of a median, shoulder, and bike lane. Further, the state park experiences unproportionally high volumes of cyclists biking up and down these roads, in addition to drivers. In 2014, these local users formed a coalition known as the *Mount Diablo Cyclists*. After gaining support from and awareness through local- and state-level officials, Mount Diablo Cyclists was able to work with the state park's civil engineer to design and implement a concept known as the "bike turnout" (auxiliary bike lanes). These are best understood as an intermediate bike lane that is located on a roadway curve where cyclists' right-of-way is redirected off the road to allow for any following vehicles to pass. A wide array of existing literature, news articles, and social media posts have been investigated to determine if any similar practice exists on a similar scale; however, to this day, no peer-reviewed literature or state- or federally mandated engineering guidance have acknowledged auxiliary bike lanes.

These have proven to be effective at Mount Diablo State Park and warrant formal research methods to investigate the large-scale applicability of bike turnouts. When considering its applicability to Oregon roads and drivers, the users' stated preference perceptions of bike turnouts should be explored to increase the likelihood that their implementation will produce desirable outcomes.

1.1 RESEARCH OBJECTIVES

The overarching research question is, *what are drivers' perceptions of auxiliary bike lanes on narrow, horizontal curves with limited sight distance?* From this, the primary research objective was derived, and is to develop additional confidence in user (bicyclist and motorist) comfort and preference in the presence of auxiliary bike lanes along limited sight distance roadway curvature. The results and deliverables of this study are intended to develop the safety (perceptual and observed) and user experience metrics to determine if auxiliary bike lanes are feasible treatments for applications like those tested in this project.

1.2 ORGANIZATION OF REPORT

This report is organized to ensure accurate interpretations of the results. The scenario-specific research methods pertaining to the analysis of the open-ended responses will be simultaneously presented alongside the results. The first of five sections introduced the literature review, covering the background of vehicle-overtaking-cyclist maneuvers, the concept and development of the *auxiliary bike lane*, vehicle-overtaking-cyclist crash statistics, and lastly, relevant literature. The second section, *Research Methods*, presents how the research objectives were met: the survey samples, distribution methods, and survey design. Following is the *Results* section which first covers the overall quality of the data and then the demographics of each participant sample. Correspondingly, a summary of respondents' relevant experience as a road user is provided, including the experiences of both cycling and non-cycling drivers and conversely the experiences of the driving and non-driving cyclists. Following is the presentation of the results on a per-scenario basis where the results from each survey are presented simultaneously. The last subsection of the *Results* summarizes respondents' perceptions of bike turnouts with respect to the post-education stated-preference questions. The fourth section, *Discussion*, focuses on the results from niche groups who would likely utilize bike turnouts and secondly, the results from participants who have been to Mount Diablo State Park and encountered auxiliary bike lanes. The fifth and final section presents a general summary of the study and the corresponding conclusions and recommendations for future work and bike turnout design.

2.0 LITERATURE REVIEW

This chapter introduces auxiliary bike lanes, conceptualized and designed by Mount Diablo Cyclists (MDC) and California State Parks and implemented on shared roadways in Mount Diablo State Park. Given their novelty, no peer reviewed literature on their user perception, performance, or impacts on safety is currently available, nor is there available design guidance. First, the background of the scenario of interest will be provided. Following, a synthesis of self-reported data, historical archives, and documentation on Mount Diablo Cyclist's website, will be presented. Alongside this synthesis will be information from an interview with the MDC president, Alan Kalin. Lastly, relevant crash counts will be presented and synthesized.

2.1 BACKGROUND

Inherent to roadways with variable horizontal and vertical curves is the potential for restriction of sight distance for all users. When a cyclist is traveling with traffic along these curves, there is an increase in risk associated with motorists relying on insufficient or obstructed sight distance for decision making. The implications this has on driver and cyclist safety vary in magnitude and type but are conditioned on the roadway characteristics. On two-lane, undivided roadways (often rural), not only is sight distance further constrained, but the crash severity potential increases. On these segments, the margin of error decreases as the available horizontal clearance is constrained, i.e., no or limited paved shoulder, or no bicycle lane. Even when shoulders are present, there remains inconsistency in widths, with many being insufficient for driver and cyclist comfort and safety during an overtake maneuver. In scenarios where cyclists do not have a sufficient shoulder (e.g., it is too narrow or not paved) or do not have a bicycle lane, upon approaching the cyclist, the motorist has three viable options:

- Continue traveling behind the cyclist for the remainder of the roadway segment until a bike lane/paved shoulder, median, or passing lane become present such that the motorist does not have to overtake the cyclist,

- Stay behind the cyclist until there is a section of roadway with sufficient sight distance to safely travel into the opposing vehicle lane, then overtake the cyclist, or

- Enter the opposing vehicle travel lane on a horizontal and/or vertical curve to overtake the cyclist.

As defined by Kovaceva et al., the act of a vehicle overtaking a cyclist can be separated into four phases: approaching, steering away, passing, and returning (Kovaceva, Nero, Bärgman, & Dozza, 2019), and are schematically depicted in Figure 2.1.

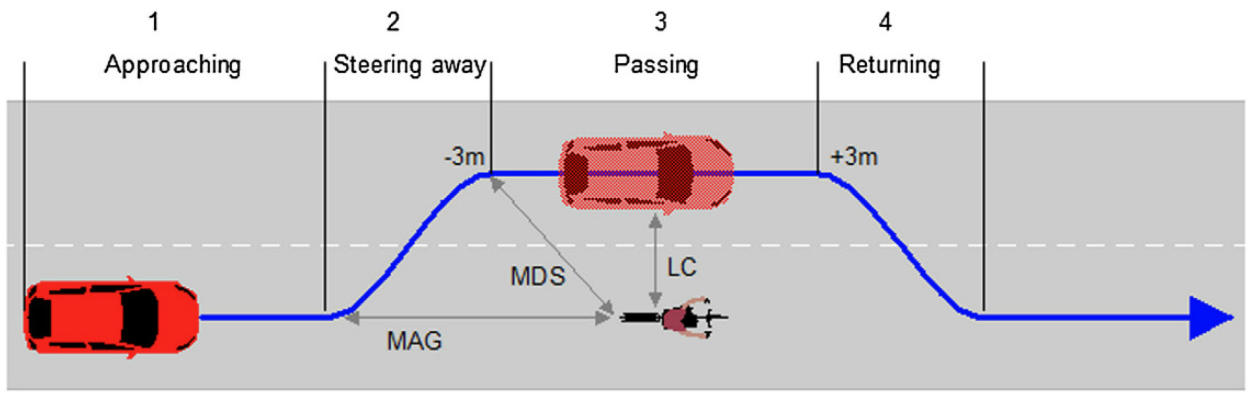


Figure 2.1: Phasing of a motorist overtaking a cyclist (Kovaceva et al., 2019)

The risk associated with overtaking a cyclist is a direct result of the motorist deciding to enter and transition between phases - like an intersection approach, the transition between these phases can introduce dilemmas. For a motorist to successfully execute an overtaking maneuver, they must have the mental capacity and visual capability to do the following:

- From the first phase, motorists must correctly judge and control their relative distance to the cyclist, across time – from the beginning of the approach to the end of the return.

- During the dilemma zone upon steering away (entering the opposing travel lane), motorists must correctly detect and judge the opposing traffic speed and trajectory to gauge the longitudinal space available, assess downstream roadway conditions to anticipate for opposing vehicles entering the travel lane, and precisely judge their distance from the cyclist.

- During passing, motorists must do the following in real time: and gauge the available space between any opposing traffic and control the speed, accordingly, continually assess downstream conditions to anticipate for opposing traffic entering the roadway and maintain awareness of their lateral proximity to the cyclist, and the cyclist's speed.

- Upon returning to their travel lane, the motorist must gauge the available space between their rear bumper and the cyclist, the cyclist's speed, and their distance from any oncoming traffic.

All of this is to show that the safe execution of an overtaking maneuver imposes a notable mental workload on motorists. Moreover, there are many opportunities for motorists to make incorrect judgements and act upon them, where the consequence could be a crash.

To eliminate the need for motorists to enter the opposing travel lane whilst overtaking a cyclist, a paved shoulder or bike lane could be added along these segments. However, given that the conditions of the problem are focused on rural roadways located in non-level, mountainous, variable-grade terrain, the feasibility of extending the pavement width is highly dependent upon multiple factors. The first being that there is a higher chance that the surrounding land is privately owned, where the right-of-way (ROW) needed to build a bike lane or shoulder would require a transfer of ownership at some cost. Secondly, the constraints imposed by the geometric alignment may result from the preexisting, surrounding landscape – heavily wooded, steep slopes, and unmaintained land that may not afford the opportunity to be excavated and cleared. These very factors are often the reason for the exclusion of paved shoulders and bike lanes in original design plans.

While these implications and constraints are represented along many rural roadways in the United States, when there is a significant enough demand for cyclists and vehicles operating along the same roadway segments at the same time, vehicle-bicycle collisions begin occurring with greater frequency. Beginning in 2010, on the two-lane, undivided roadways in Mount Diablo State Park (MDSP), vehicle-bicycle collisions increased with growth in vehicular demand. To address this, a coalition of cyclists known as the Mount Diablo Cyclists was established in 2014 by Alan Kalin. They proposed a solution to provide cyclists dedicated roadway widths along blind curves termed “bike turnouts” (Kalin, 2023).

2.2 AUXILIARY BIKE LANES

2.2.1 Timeline

MDSP, located in Clayton, California, is a popular destination for road cycling. To reach its attraction, the summit of Mount Diablo (3,849 feet), the state park offers users three main paved roadways: South Gate Road, North Gate Road, and Summit Road, with a total elevation gain of roughly 3,156 feet ("Mount Diablo Challenge," 2022). Given the mountainous terrain of MDSP, these roadways exhibit many horizontal and vertical curves, with over 300 being considered blind curves ("Eastbay Times Newspaper," 2017). To access most activities (e.g., mountain biking, hiking, trial running), visitors must use these roadways to get to the trailheads. In addition to vehicular demand, these three main roadways experience proportionally high demand from road cyclists. According to the MDSP Superintendent, in 2014, a total of 130,000-150,000 cyclists rode up Mount Diablo (MD) where on a typical weekend, 500 motorists shared these paved roadways with 700 cyclists ("Our Story," n.d.). According to Strava, a GPS-based exercise tracking platform popular among cyclists, 17,835 of its users have biked up North.

Gate Road on or before Dec. 10, 2023. Further there have been a total of 64,505 completions of North Gate Road, yielding an average of 3.6 trips up Mount Diablo per rider, corroborating its popularity and providing insight into its familiarity among its user base ("Mount Diablo Challenge," 2022). With this high demand from both cyclists and motorists comes a greater opportunity for vehicle-bicycle collisions. From 2005 to 2015, 77% of all cycling-related crashes occurred on these three roads, with the remaining 23% occurring on unpaved trails ("65 Bike vs Vehicle Collision: 2002 to October 2022," n.d.). Since 2022, MDC have reported 65 vehicle-bicycle collisions[1].

[1] Since 2014, California State Parks has not been willing to share its data with MDC, and hence there may be collisions unaccounted for. The data MDC publishes on their website comes from their “research and analysis” of California State documents (obtained via Public Records Act) and the California Highway Patrol (CHP) Integrated Traffic Records System (SWITRS).

The president of MDC, Alan Kalin, was interviewed by Helena Breuer via Zoom on February 3, 2023, to learn more about the evolution of Mount Diablo Cyclists and the subsequent development of auxiliary bike lanes.

Beginning in 2010, cyclists frequenting Mount Diablo became more aware of and started experiencing more near-miss and "near-death" incidents. Most commonly, stories regarded incidents where motorists would overtake ascending cyclists on blind curves and hit cyclists on their descent. According to MDC, California State Parks took no precautions to address, mitigate, or investigate these scenarios. As a result, Kalin established Mount Diablo Cyclists in 2014. Shortly following in 2015 and in 2016, via the Public Records Act, Kalin analyzed 100+ vehicle-bicycle collisions using Traffic Collision Reports (TCR) from California Highway Patrol (CHP) CHP-555 forms, California State Parks Public Safety Reports (DPR 385/386), and data from the Statewide Integrated Traffic Records System (SWITRS). Following the assessment of this data and working with the CHP, Kalin realized that 80% ("commonality factor") of all vehicle-bicycle collisions occurred on or near blind curves (Kalin, 2023). Subsequently, Kalin took initiative and conceptualized the bike turnout, writing, "I got the idea from thinking about a car turnout, why not a Bike Turnout on Mount Diablo. I established a small Turnout Working group, we started in my backyard to design a Bike Turnout. No engineer involved, just used common sense, analysis and logic to design the concept for a Bike Turnout" (Breuer & Kalin, 2023).

Throughout 2016, public awareness of MDC's mission grew as local news stations were broadcasting stories about MDC. Further, MDC began working with California State Senator, Steve Glazer, to raise funding for safety improvements on the three main cycling roads in MDSP. In 2016, funding was generated to install 35 "Do not pass bikes on blind curves" signs, 35 "Avoid crash slow down" signs, bike shares every half-mile on ascending lanes, additional stop signs, revised warning and speed signage, and solid double yellow centerlines (Trujillo, 2016).Shown, in Figure 2.2 is Senator Steve Glazer pictured with a sample of each sign.

Figure 2.2: Samples of signs installed from 2016 funding initiative. Source: ("Our Story," n.d.)

During that same year, three "test" bike turnouts were installed in MDSP as a pilot study.

According to MDC, after the installation of these safety improvements, motorists traveling uphill were still crossing solid double yellow lines to pass cyclists and hence met with Park Leadership in February 2017. California State Parks stated “we are not going to do anymore” with respect to improving the safety on Mount Diablo ("Our Story," n.d.). Consequently, MDC pursued support from local organizations and elected officials. In December 2017, Senator Steve Glazer and Assemblywoman Catharine Baker sent a letter to the director of the California Department of Parks and Recreation, Lisa Magnat, requesting that they “develop a plan to implement the overall auxiliary bike lanes program”. Additionally, the letter stated the request for an “immediate installation of the 10 to 11 bike turnouts”. On February 1, 2018, the installation of 10 new bike turnouts was completed. Figure 2.3 is a screenshot from a drone video taken by MDC of one of these turnouts.

Figure 2.3: Bike turnout from 2018 installation project. Source: (“BIKE TURNOUTS MOUNT DIABLO STATE PARK,” 00:00:24)("Our Story," n.d.)

To add to their argument, in 2017 and 2018, MDC conducted two surveys on motorists’ and cyclists’ perceptions of bike turnouts and their perceptions of proposed signage. The first survey (motorists only) was conducted in 2017 and yielded 100 motorist responses – where 100% of motorists believed bike turnouts would allow them (motorists) to pass bicycles without crossing the solid double yellow lines ("Motorist Safety Survey," n.d.). On January 1, 2018, MDC distributed surveys to cyclists at their first “Share The Road” safety event, which yielded 128 responses. MDC reported that 100% of this cyclist sample indicated they would use bike turnouts to allow cars to pass. In this survey, MDC presented a proposed sign stating, “Do not pass bikes on blind curves”. Overall, 88% of cyclists supported the “Do not pass bikes on blind curves” this sign, with many cyclists stating that it would act as a reminder and increases driver awareness ("Cyclist Survey," n.d.).

Since 2017, 45 auxiliary bike lanes have been installed on MDSP roads, with the recent completion of 28 bike turnouts on October 15, 2022 ("45 Bike Turnouts," n.d.).

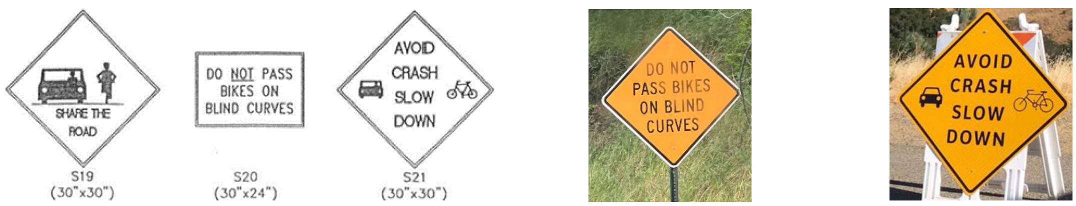
2.2.2 Design Specifications and Guidance

Via the historical archives provided on MDC’s website, some design specifications of the bike turnouts were obtained from the engineering plan set corresponding to the most recent installation in 2022 which were approved by David W. Lofholm (PE License No. C83449)

(Lofholm, 2022). Additionally, MDC archived the engineering plan set from the 2016 project which contains the drawings for the signage addressing the vehicle-overtaking-cyclist maneuver; these plans were approved by Leopoldo Trujillo (PE License No. 63950)(Trujillo, 2016). The research team contacted California State Parks in an attempt to obtain the engineering drawings from the first installation (3 turnouts) and the second installation (10 turnouts), however, no response has been received.

2.2.2.1 Signage

Figure 2.4 shows the drawings and images of signage outlined in the engineering plan set, *Mount Diablo State Park Roadway Signing & Striping Improvements,* provided by Mount Diablo Cyclists.



A B C

Figure 2.4: Mount Diablo State Park Signage: (A) Engineering Drawings for Signs S19-21, Source: (Trujillo, 2016); (B) Sign S20; (C) Sign S21, Source: ("Our Story," n.d.)

Since the implementation of the bike turnouts in 2017, four additional signs were proposed according to an archived set of memorandums ("Bike Turnout Project #2019-05 Mount Diablo State Park," n.d.). While no drawings or design specifications were provided, a table of these signs' location, sizes, and descriptions was provided. Throughout MDSP, one sign described as "No Parking Anytime [with] Arrows" and four signs described as "No Parking [with] Arrows" were stationed separately along five bike turnouts. Nine signs described as "Bicyclists Must Use Turnouts", were individually located throughout the park in advance of nine bike turnouts. Lastly, nine signs described as "Pass at Turnouts and Passing Lanes (car image on top of sign)", were located throughout the park along ascending travel lanes.

2.2.2.2 Striping

In the 2022 plan set, the bike turnout and three modified variations were drawn. For compatibility purposes, the drawing of the primary bike turnout was redrawn, close to scale, by the author. All relevant design specifications were added to this figure. The remaining specifications and notes are accessible from the corresponding engineering plan sheet in Appendix A.

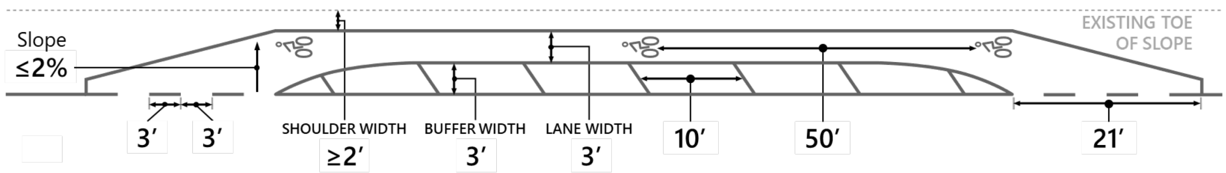


Figure 2.5: Alternative Drawing of Bike Turnout from Engineering Plan Set

There was minimal design guidance for the portion of the roadway that transitions the cyclist off the travel lane (entry point) and back onto the travel lane (re-entry point). According to Drawing 1 on page C4.0, only two specifications were relevant: (1) the distance between the start station and the start of the buffer is 21 feet, and (2) the dashes at the re-entry point are 3' long (Lofholm, 2022). This plan set did not provide any design guidance for determining the starting and ending position, with respect to the roadway's point of curvature and tangency. Additionally, all archived documentation and plan sets on the MDC website were thoroughly scanned for this design guidance.

2.3 MOTORIST-OVERTAKING MANEUVER CRASH STATISTICS

The roadway geometry, presence of cyclists, and vehicle-overtaking-cyclist collisions are not unique to MD and are observed across the United States. To provide a better understanding, the Fatality and Injury Reporting System Tool (FIRST) was employed to query Fatality Analysis Reporting System (FARS) data on fatal and non-fatal (cyclist) vehicle-bicycle collisions where the motorist was overtaking the bicyclist. Additional FARS data filters were applied to refine the statistics to represent the geometric conditions and the crash factors in the problem statement. It should be noted that given the available filters, this queried data does not include crash statistics exclusive to all conditions defined in the problem statement, and likely includes additional crashes that may not meet the additional criteria – the geometric alignment of the roadway (e.g., horizontal/vertical curves), the width of roadway (excluding travel lane) available to cyclists, and limitations to sight distance (e.g., geometric constraints, physical obstructions). When assessing the crash statistics, it is important to consider these caveats before making judgements and observations. All reported crash statistics were first filtered to meet the following criteria:

- Bicyclist direction of travel was 'with traffic,'
- Bicyclist position was on 'travel lane' or 'bicycle lane/paved shoulder/parking lane,'
- The crash location was 'not at intersection,'
- The crash type was 'motorist overtaking' – which included the following subclasses: undetected bicyclist, misjudged space, bicyclist swerved, other/unknown, and
- The crash was in a 'rural' environment.

From 2014 to 2020, there were a total of 601 fatal vehicle-bicycle collisions in rural environments, where the driver was overtaking the cyclist (Table 2.1). Cyclist fatalities make up 94% of these collisions, with 563 total fatalities, whereas only 6% of the time, the cyclist was injured (injured, incapacitating or injured, non-incapacitating or injured, or other). Of the fatal vehicle-bicycle collisions – 495 of these collisions occurred with the cyclist in the travel lane and 70 occurred with the cyclist was positioned in the bicycle lane/paved shoulder/parking lane. Within this queried data, the data was further disaggregated to only include crashes in Oregon. Since 2014, there have been a total of 10 cyclist fatalities in rural environments during a motorist overtaking the cyclist on Oregon roadways ("Fatality and Injury Reporting System Tool (FIRST)," 2022). Using the provided web map tool, the latitude and longitude of each of these crashes are outlined in the following table, with the corresponding dates, relevant roadway characteristics, and fatality counts.

Table 2.1: Cyclist Fatalities in Oregon (Motorist-Overtaking, Rural)

Fatality Count	Year	Month	On Curve?	Bike Lane	Lat/Long Coordinates
1	2020	September	Yes	Not present	43.45685760286066, -124.2294082748209
1	2020	May	No	Not present	45.78135789956592, -119.1986138097315
1	2020	April	No	Not present	44.07052601620352, -123.22953941842685
1	2019	December	No	Not present	44.057735269409754, -123.2538347020521
1	2018	June	No	Not present	45.64678971700304, -118.68406942927741
1	2016	October	No	Not present	44.81038141286184, -122.83743585944772
1	2016	August	No	Not present	42.17705917094394, -120.37206985726962
2	2015	September	No	Not present	45.33095938194547, -123.05957581869816
1	2014	September	Yes	Not present	45.43545593782028, -123.89872530405769

These aggregated statistics provide reasoning and understanding that cyclist fatalities and injuries, due to motorist overtaking maneuvers is not exclusive to MD. The lack of granularity of data, with respect to event-level crash factors (alignment, bike lane, etc.) presents a gap in research surrounding vehicle-bicycle collisions on blind curves. Not only does this gap include bike turnouts, but it extends to the study of vehicle-bicycle collisions on blind curves due to overtaking maneuvers. There exists international research studying vehicle-bicycle collisions due to overtaking maneuvers; however, these studies do not exclusively explore and investigate these collisions on vertical and horizontal curves.

2.4 RELEVANT LITERATURE

Upon an extensive literature search, only one publication was located within the United States that analyzes and presents geometric alignment-specific vehicle-bicycle collisions at state-level scale. Robarates and Chen assessed and analyzed over 2,400 police reported collisions from 2010 to 2014 in the State of Virginia, comparing crash statistics, by injury level, across a variety of environmental, roadway, vehicle, and user factors (Robartes & Chen, 2017). It is important to note that crash statistics were not reported by type and as such, the counts and conclusions are inclusive to all vehicle-bicycle collision types and are not exclusively representative of overtaking maneuvers. However, Robarates and Chen reported injury-level crash counts, by lane configuration and geometric alignment, individually which is of relevance.

In this study, the model suggests that two-way, divided (with and without a median) and one-way roadways are less dangerous than two-way, undivided roadways. Of all reported collisions, 53% (1,281 total) were reported to have occurred on two-way, undivided roadways, resulting in 11 cyclist fatalities and 330 cyclists severely injured. This variable was found to be statistically significant at the 95th percentile (Robartes & Chen, 2017). While there were limited statistics classified by lane configuration, the statistics by alignment were more detailed. Table 2 was created as a summary of the reported vehicle-bicycle collision counts for each non-level alignment by injury severity from (Robartes & Chen, 2017).

Table 2.2 provides a summary of the reported cyclist fatalities and injuries by motorist overtaking maneuvers on two-way, undivided roadways in Virginia from 2010 to 2014 (Robartes & Chen, 2017).

Table 2.2: Injury-Level Crash Counts by Alignment Type

Severity	Horizontal Curve	Vertical Curve	Hill/Dip
Fatal	3	3	2
Severe Injury	50	122	19
Minor Injury	72	210	39
No Apparent Injury	15	42	12
No Injury	3	14	2
Total	143	391	74

The first two alignment conditions, the presence of a horizontal curve and a vertical curve, were found to be statistically significant to the 95th and 99th percentile, respectively. The model suggests that when a vehicle-bicycle collision occurs on an alignment with a grade, there is a 79.2% chance for the cyclist's injury level to be fatal. Moreover, compared to straight roadway segments, the model suggests that vehicle-bicycle collisions on horizontal curves are 95.7% more likely to result in a cyclist fatality (Robartes & Chen, 2017).

2.5 LITERATURE REVIEW SUMMARY

The vehicle-overtaking-cyclist maneuver poses significantly more risk under conditions that many rural, mountainous roadways in Oregon exhibit: two-lane roads with no shoulder, horizontal curves, and geometric design and existing vegetation that restricts sight distance. Under such conditions, cyclists will likely be pedaling at speeds less than 5 miles per hour. For a driver following the cyclist, at the speed of the cyclist, the added travel time is perceived as a burden. This lost time is only further exacerbated when vehicles arrive, resulting in a growing queue length whose dissipation rate is constrained.

At Mount Diablo State Park, vehicle-overtaking-cyclist collisions were overrepresented on 'blind' curves, often resulting in serious cyclist injuries. To address this, Alan Kalin, president of Mount Diablo Cyclists, created the concept known as the *bike turnout*, which in 2016 was first implemented and since has been proven to reduce these collisions. Given their novelty and subjectivity to Mount Diablo State Park, ubiquitous, evidence-based design guidance and formal criteria for implementation do not exist.

Across the United States, between 2014 and 2020, there were 601 fatal vehicle-overtaking-cyclist collision, specifically in rural environments. Of these fatalities, ten occurred on rural Oregon roadways, absent of a bike lane or shoulder. Statewide, the integration of auxiliary bike lanes has great potential to save lives and improve users' level of comfort but requires further investigation into its receptivity and perceived benefits among Oregon drivers and cyclists.

3.0 RESEARCH METHODS

Qualtrics, an online survey builder that OSU maintains a software license for, was used to build and distribute the driver and cyclist surveys. In the following section, the research methods used to develop and distribute the online surveys are presented. First, the target audiences and proposed sample sizes, per survey, will be introduced. Next, the online distribution methods and imposed per-capita quotas will be outlined. Lastly, the experimental design and resulting survey design will be explained.

3.1 TARGET SAMPLES

A total of 600 individuals, 18 years or older, across the state of Oregon were recruited to participate in the study. Of the total sample, 300 licensed drivers were recruited for the driver survey and 300 active bicyclists were recruited for the cyclist survey.

Qualtrics recruited participants based on state of residence (Oregon) and user type: driver or cyclist. To further ensure each participant met the criterion for the surveys, three screening questions were asked at the beginning of the survey. For a respondent to participate in the driver survey, they had to be a licensed driver and had to have driven a vehicle in the past 6 months. Similarly, for a respondent to participate in the cyclist survey, they had to be an active user of a bicycle on Oregon roadways and had to have ridden a bicycle in the past 6 months. Persons who did not meet the criteria were cordially redirected to the end of the survey and were thanked for their time. On the backend, Qualtrics inhibited any individuals who clicked on the survey invitation a second time after being excluded, to circumvent the screening questions.

3.2 DISTRIBUTION METHODS

According to Qualtrics, multiple channels are used for sampling. Potential respondents were sent an email from Qualtrics inviting them to participate in the survey, stating the estimated time required (10 minutes) and providing readers with a direct link to the survey. At the beginning of the survey, respondents were told that their participation would contribute to the improved safety of cyclists and drivers on Oregon roads and that upon completion, they could enter for a chance to win a $50 Amazon gift card.

3.2.1 ODOT Region Quotas

To represent the population distribution across Oregon, two levels of geographical quotas were enforced within each survey sample. These quotas were designed using the county-level populations mapped against the five ODOT Regions. The first quota level enforced the distribution to be spread proportionally across the ODOT Regions, with each sample size shown in Table 3.1.

Table 3.1: ODOT Region-Level Quotas

ODOT Region	Estimated Population (July 2022)		Driver Survey (n=300)	Cyclist Survey (n=300)
	n_{Region}	$\%_{Total}$		
1	1,569,165.8	36.6	110	110
2	1,637,642.0	38.2	115	115
3	513,432.4	12.0	36	36
4	370,460.1	8.7	26	26
5	191,150.8	4.5	13	13
Total	4,281,851.0	100.0	300	300

Given that each region was made up of a group of counties, a second quota level was employed to proportionally represent each county's population with respect to the total region population, as shown in Table 3.2. There were minimum quotas enforced, however, for counties of significantly lower population sizes, it was unfeasible to reach the target sample size in the time allotted.

It is important to note that Washington County is geographic split between ODOT Regions 1 and 2 and for the purpose of defining the quotas, their population was split 50/50 between the two regions.

Table 3.2: County-Level Quotas

ODOT Region	County	Percent of Region Population	Target Sample Size
1	Clackamas	27%	30
	Hood River	2%	2
	Multnomah	52%	57
	Washington (R1)	19%	21
2	Benton	6%	7
	Clatsop	3%	3
	Columbia	3%	4
	Lane	23%	27
	Lincoln	3%	4
	Linn	8%	9
	Marion	21%	24
	Polk	6%	6
	Tillamook	2%	2
	Yamhill	7%	8
	Washington (R2)	19%	21
3	Coos	13%	5
	Curry	5%	2
	Douglas	22%	8
	Jackson	44%	16
	Josephine	17%	6
4	Crook	7%	2
	Deschutes	56%	15
	Gilliam	1%	0
	Jefferson	7%	2
	Klamath	19%	5
	Lake	2%	1
	Sherman	1%	0
	Wasco	7%	2
	Wheeler	0%	0
5	Baker	9%	1
	Grant	4%	1
	Harney	4%	1
	Malheur	17%	2
	Morrow	6%	1
	Umatilla*	42%	6
	Union	14%	2
	Wallowa	4%	1

3.2.2 Timeline

The distribution of both surveys began in August 2023. For the driver survey, the data collection was completed in 3 weeks. Whereas for the cyclist survey, data collection was completed in 4 weeks.

3.3 SURVEY DESIGN

3.3.1 Approach

This research was initially proposed to survey users' experiences and perceptions of auxiliary bike lanes following their implementation on McKenzie Pass; however, the construction timeline was postponed such that an alternative approach was required. It was fixed that an online survey would be the instrument of data collection, where the initial exposure to and presentation of auxiliary bike lanes was down selected to two potential mediums – simulation-based videos or "on-site" videos captured at Mount Diablo State Park. The latter was selected as the most feasible and time-sensitive option. Moreover, given the novelty of bike turnouts, selecting a simulation-based approach would take away from the reality of auxiliary bike lanes and hinder the elicitation of users' true perspectives. Further, simulation-based approach would require additional time for development of the virtual environment. Considering these factors, and the relative feasibility of the on-site approach, the research team traveled to MDSP to capture point-of-view (POV) videos of bike turnouts.

To eliminate inconsistency and resulting bias between user perspectives, the videos were recorded simultaneously, as each other's equal and opposite pair. To capture videos in parallel, the research vehicle was equipped with a DJI Osmo Action, and the bicycle was equipped with a DJI Osmo Action 3. The settings of each camera were set to the following values:

- Resolution: 4K, HD
- Framerate: 60 frames per second (fps)
- Stabilization: Rocksteady (on)
- Field of View (FOV): Wide

To obtain the driver's perspective videos, the DJI Osmo Action was mounted to the hood, closest to the windshield, where the camera was laterally positioned to be in-line with the driver's center of vision. To obtain the cyclist's perspective videos, the DJI Osmo Action 3 was mounted to the top tube (cross bar) of the bicycle and angled to show the handlebars with the cyclist's hands in the view.

The researcher team, consisting of three graduate research assistants, conducted video recordings over two days. Upon arriving at MDSP, roadway curves that were representative of the baseline and existing conditions were identified for the Scenario 1 and 2 POV videos. For Scenario 3, four separate auxiliary bike lanes were down selected from more than 60 auxiliary bike lanes in MDSP. Multiple trials of recordings were conducted at each of these road segments. Per scenario, the best POV video-pair was determined and further compared against the POV video-pairs from each segment. The POV video-pairs selected for the survey were chosen based on the interaction timing.

For each video, two researchers drove in the research vehicle upstream, approximately half of a mile, from the recording site and the cyclist bike a few hundred feet upstream. Each researcher started the video recording once at their respective upstream location. Once the researcher driving got to a specific location, they honked their horn to alert the cyclist researcher to begin biking. For each recording location, this method was trialed multiple times to identify the starting and honking locations that would allow for the interaction of interest to precisely occur at the identified passing locations. Each researcher ended the recordings once the opposing researcher was not in their field of view.

Following the site visit, each scenario's POV video-pair was edited and cropped to start 3-5 seconds before and end 3-5 seconds after the location of interest. Lastly, these videos were uploaded to YouTube for the Qualtrics in-survey video integration tool.

3.3.2 Design

Each survey consisted of fixed-choice and open-response questions to obtain the user perceptions and receptivity of auxiliary bike lanes among Oregon drivers and cyclists. Both versions of the surveys are provided in Appendix C and Appendix D, respectively. Collectively, the Driver Survey consisted of 32 questions (29 fixed choice and 3 open-ended response). The Cyclist Survey consisted of 35 questions (32 fixed-choice and 3 open-ended response). The design and structures of both surveys are consistent in terms of the order of presentation and questions. All questions regarding user perspectives are identical but tailored to the user type. Figure 3.1 is a semi-descriptive flow chart for the cyclist survey and outlines the order of sections and questions and is also representative of the driver survey structure and flow. Following, the different sections and questions are detailed in greater depth.

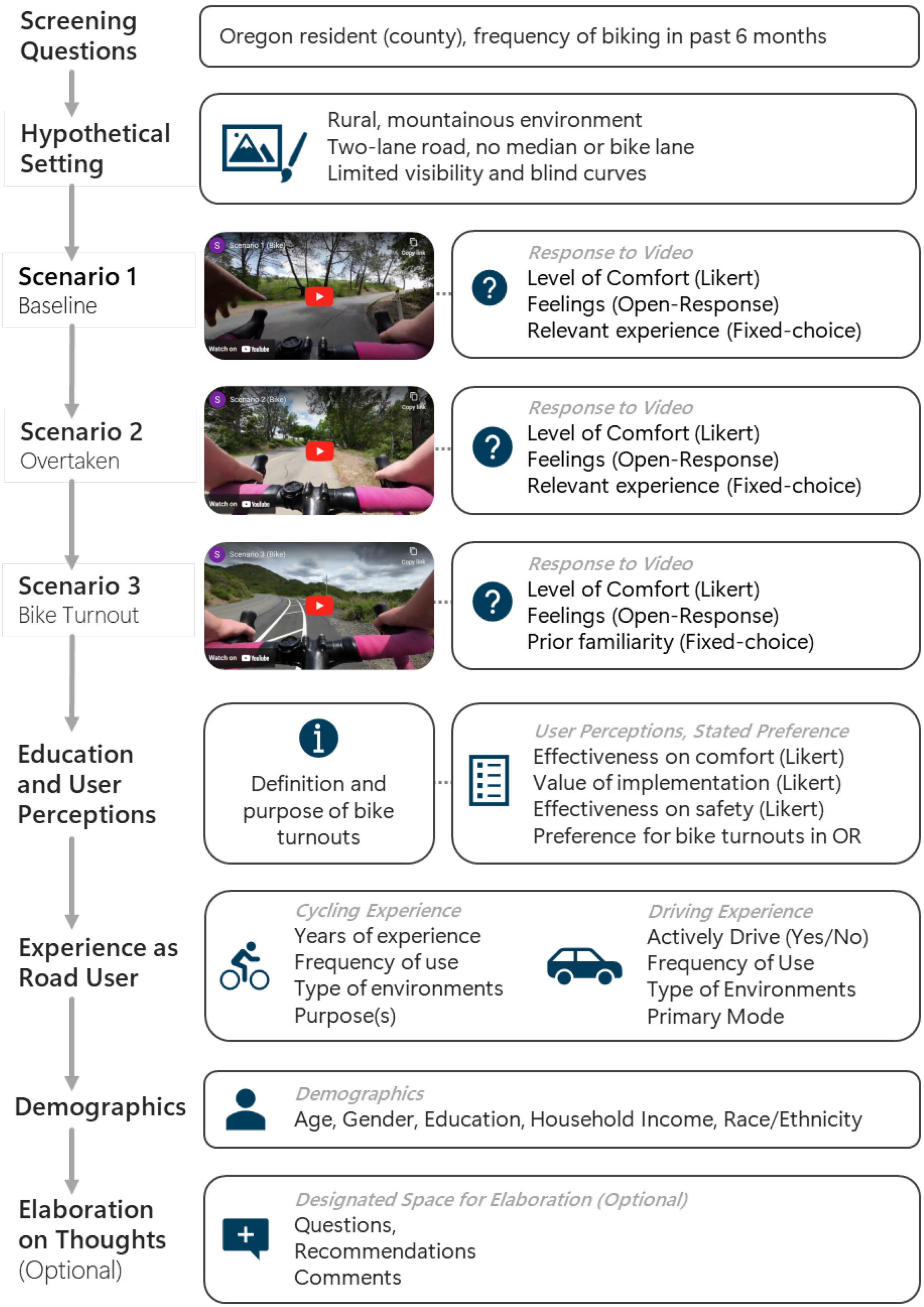


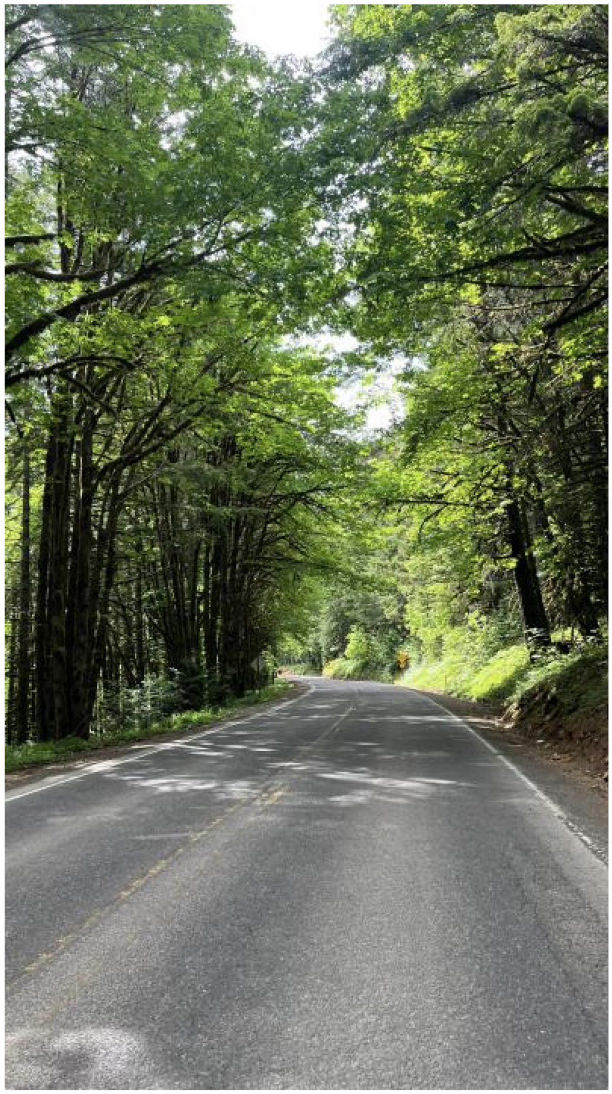
Figure 3.1: Flowchart of Cyclist Survey

The survey was designed to study three scenarios representing baseline, existing, and proposed conditions, in that respective order. Before introducing these scenarios, respondents were provided with descriptive text and pictures that illustrated the environment they would be driving or biking through. Further, this explicit definition was used to ensure there was a uniform understanding of the subject roadway environment. In Figure 3.2, screenshots show what drivers were presented with. Cyclists were presented with the exact same content and pictures where the wording was modified from a driver's perspective to a cyclist's perspective.

The videos you will be watching are recorded from the driver's point of view to simulate an experience of you driving on the roadway.

It is important for you to *feel* and have the mindset as if you are *actually* driving, so to help you do this, let us first get a better understanding of the type of road and environment you will be 'driving' in...

Imagine it is a bright, clear summer day and you are driving up a mountain range in Oregon, on a two-lane rural highway with **no median**, **no bike lanes**, and **no shoulders**, similar to the road in the image below.



In addition to other drivers, cyclists are known to bike **up and down** this roadway.

Figure 3.2: Driver Survey Screenshots: Hypothetical Roadway Environment
(figure continues next page)

Initially, there were some gradual hills and curves connected by stretches of flatter and straighter road. Here, you were able to *easily* and *safely* pass cyclists.

Now you are approaching more mountainous terrain, where the road is winding, with **steeper** gradients and **tighter** curves, similar to the road in the image below.

Figure 3.2 (continued): Driver Survey Screenshots: Hypothetical Roadway Environment

Participants experienced each scenario through a POV video from the perspective of the corresponding user type (motorist or cyclist). Following each video, a short series of reflective questions were asked to obtain information regarding their level of comfort, feelings, and relevant experience/familiarity with the scenario. After the Scenario 3 (initial exposure to a bike turnout) module was completed, participants were informed of the concept and application of auxiliary bike lanes. Post-education questions were then asked to obtain participant's level of comfort, perceived safety, and their preference for or against auxiliary bike lanes in Oregon. The proceeding survey questions aimed to gather more information on the respondent as a road user in Oregon. Following, general demographic questions were asked. After these questions, respondents were provided with time and space to express any comments, questions, or recommendations regarding auxiliary bike lanes and the space to enter their email for a chance to win the Amazon gift card. Respondents were informed that these were entirely optional and could be skipped submitting the survey.

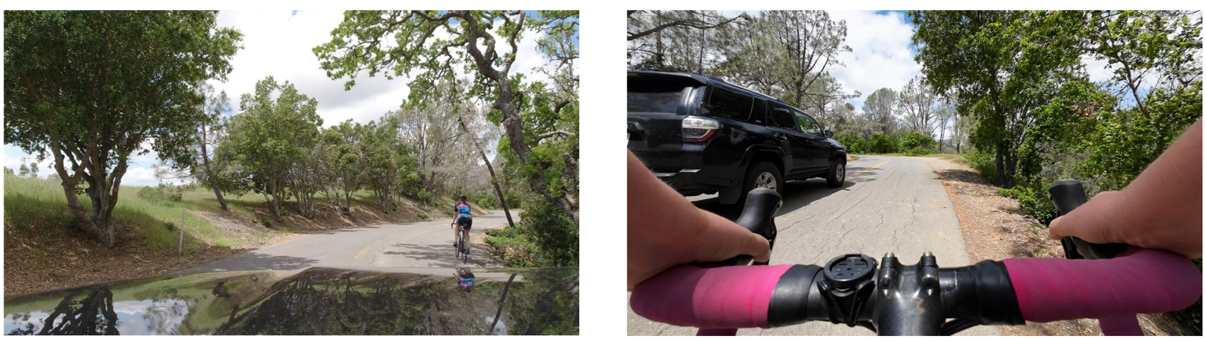
3.3.2.1 Point-of-View (POV) Videos

First, the participant experienced driving/bicycling up the segment of interest without other road users present, with screenshots from these videos shown in Figure 3.3.

Driver Perspective | Cyclist Perspective

Figure 3.3: Video Screenshots per Survey (Scenario 1)

Next, participants experienced driving/bicycling up the segment of interest where the driver entered the opposing travel lane and performed an overtaking maneuver/the cyclist was overtaken by a vehicle whilst on the curve. Corresponding screenshots from these videos are shown in Figure 3.4.



Driver Perspective (Beginning of overtaking maneuver, cyclist on edge of travel lane) | Cyclist Perspective (Mid-overtaking maneuver, vehicle overtaking by entering opposing travel lane)

Figure 3.4: Video Screenshots per Survey (Scenario 2)

Lastly, participants experienced driving/bicycling up the segment of interest with a auxiliary bike lane present. In this scenario, the cyclist enters the bike turnout where the driver then passes the cyclist while remaining in their travel lane as shown in Figure 3.5. Upon reaching the end of the auxiliary bike lane, the cyclist safely maneuvers back onto the roadway where the vehicle is far downstream.

Driver Perspective
(Approaching bike turnout, cyclist enters bike turnout)

Cyclist Perspective
(In bike turnout, vehicle passing without entering opposing travel lane)

Figure 3.5: Video Screenshots per Survey (Scenario 3)

3.3.2.2 Response to Videos: Fixed-Choice Questions

Directly following each video, participants were presented with a 5-point Likert scale and asked to indicate their level of comfort/discomfort, "*From the [driver's, cyclist's] perspective, what was your overall level of comfort/discomfort while watching the video?*". For the baseline and existing conditions, respondents were asked additional fixed-choice questions about their experience and familiarity with the interaction of interest.

Following the Scenario 1 video in the driver survey, respondents were first asked about their familiarity with roadways like that of the one in the video and at the beginning of the survey. Secondly, drivers were presented with text describing the same conditions, but a cyclist was ahead. Drivers were then asked to indicate whether they would safely pass the cyclist or wait until a straight segment to pass the cyclist. It is important to note that this question was intentionally asked before Scenario 2, where a cyclist is introduced, to reduce the potential for order bias. Further, social desirability bias was accounted for because the question-and-answer choices were neutrally worded so respondents did not perceive there to be a "correct" answer. Lastly, after Scenario 2, drivers were asked if they have ever overtaken a cyclist on a road with similar conditions.

After the first scenario video in the cyclist survey, respondents were asked about their familiarity with biking on roads like that of the one in the video and at the beginning of the survey. Next, cyclists were told to imagine biking on the same road, but a driver is approaching from behind and then asked to select what best describes their response: getting off the bike to let the vehicle pass, moving to the outer edge, or temporarily moving to the center of the lane to prevent the vehicle from passing on the curve. Following Scenario 2, cyclists were asked about their familiarity and level of comfort/discomfort with being overtaken by a vehicle.

3.3.2.3 Response to Videos: Open-Ended Response Questions

Inductive coding procedures, including sentiment and aspect analyses, were employed to analyze the open-response questions. It should be noted that codes were developed on a per-scenario basis, and hence, there is no uniform set of codes within each survey. Before proceeding

Per scenario, all responses were manually read and assessed with respect to the scenario. Before proceeding to conducting sentiment or aspect analyses, all non-sequitur responses were identified and coded. All responses were coded as responsive or non-sequitur (NSQ). Non-sequitur responses are responses that are comprehendible but ultimately do not answer the question. Identifying these responses is simple when they are completely irrelevant and off topic; however, the range in relevancy ranges among non-sequitur responses. Here, ambiguity arises when they are seemingly relevant or are absent proper wording. Given the made-up question, "*How do you feel about Oregon roadways?"* open-ended responses (not from survey responses) would be coded accordingly, as shown in Table 3.3. Responses that could be perceived as non-sequitur but are considered responsive are shown in the second row.

Table 3.3: Exemples of Non-Sequitur Responses

Question: ***How do you feel about Oregon roadways?***	
Assigned Code	**Hypothetical Responses**
Non-sequitur	• "I am busy this afternoon" (irrelevant) • "Sure" (not sufficient and vague) • "I drive on them" (relevant but does not indicate feelings)
Responsive	• "I like biking a lot" • "Not sure"

Per scenario, a small batch (10%) of responses were randomly selected for review. From these responses, potential themes and corresponding codes were created. Following, a different small batch of randomly selected responses were assessed to verify the usability of the drafted codes. Moreover, these responses were also used to assess the degree of specificity of the code's theme. For example, the theme of safety was commonly found in the open-ended responses, however, its direction varied among responses. Depending on the corresponding count of responses, either or both "safe" and "unsafe" codes were applied.

After reading through the initial batch of Scenario 3 responses, the respondent's degree of receptivity to auxiliary bike lanes was identified as the most discussed theme. From these responses, code's values were defined to be *Receptivity* = Yes, Maybe, No, Inconclusive, or Non-Sequitur. All responses were manually read and coded correspondingly. Inherent to this process was the surfacing of more patterns and potential codes. These were then individually investigated through keyword searching – Excel's SEARCH function and a list of words/phrases (code and synonyms) were used to filter, assess, and code applicable responses.

As more responses were reviewed, synonymous verbiage and phrases were added to the keyword list. Throughout this process, the total count of coded responses was observed as a measure of the code's feasibility. After multiple iterations of keyword searching and coding, if the total count of coded responses did not exceed 10% of the total sample size, the code was deemed insignificant and removed. For each established code, this iterative keyword searching and coding process was repeated using new synonymous verbiage to ensure all applicable responses were coded accordingly.

Once the codes for each survey and scenario were defined, three team members individually assessed and coded the open-ended responses to measure interrater reliability. To mitigate bias in data reduction, the order of responses, per scenario, were randomized for each member. Once all three individual assessments were completed, all coding was compared to determine the final code values. Responses that were coded differently by different research team members were filtered and reassessed with the entire team to determine the final code.

As a general summary, the code names and data types per scenario and user type are outlined in Table 3.4. These are all formally introduced, per scenario and user perspective, in the *Results* section where the corresponding codes and values are explicitly defined and select survey responses are presented.

Table 3.4: Open-Ended Response Code Names and Value Types

Scenario	**Driver Survey**		**Cyclist Survey**	
	Code Name	**Value Type**	**Code Name**	**Value Type**
1	General Sentiment	Multiple	Level of Comfort	Multiple
	Comfort	Binary	Cautious	Binary
	Discomfort	Binary		
	Safety	Binary		
2	Disposition to Overtake	Multiple	Discomfort	Binary
	Comfort	Binary	Tolerant/Complacent	Binary
	Discomfort	Binary	Comfortable/Confident	Binary
	Unsafe	Binary		
3	General Sentiment	Multiple	Receptivity	Multiple
	Receptivity	Multiple	Safety	Binary
	Safety	Binary	Lingering Concerns	Binary

3.3.2.4 User Perceptions of Auxiliary Bike Lanes

Before surveying drivers' and cyclists' perceptions of bike turnouts, respondents were formally informed on the concept of auxiliary bike lanes, its purpose, and how they work. Figure 3.6 shows a screenshot of this survey item that was given to both drivers and cyclists. This formal introduction of auxiliary bike lanes was intentionally designed to be brief and neutral in tone and was written using generalized terminology. This survey item did not vary in wording or volume of information between the driver and cyclist survey.

The roadway treatment presented in the last video is called a "bike turnout" and is shown through drone imagery below.

The purpose of a bike turnout is to improve the safety of drivers and cyclists on hilly and/or winding road segments during which a driver wants to pass (overtake) a cyclist ahead but is conflicted as they cannot see far enough down the road to be sure there is no opposing driver or cyclist coming downhill.

Essentially, bike turnouts serve as intermediate bike lanes during which a driver can safely pass cyclists without entering the opposing travel lane, with the risk of colliding with a driver or cyclist traveling in the opposite direction.

→

Figure 3.6: Survey Screenshot: Education of Bike Turnouts

Following, respondents were asked three stated-preference, 5-point Likert questions about auxiliary bike lanes in terms of their perceived (1) effectiveness on improving their level of comfort when passing a cyclist/being overtaken by a vehicle, (2) effectiveness on reducing potential crashes, and (3) value. Most importantly, drivers and cyclists were asked to indicate their degree of preference for auxiliary bike lanes in Oregon. After this, respondents were asked about their familiarity with auxiliary bike lanes prior to the survey and if they had traveled in Mount Diablo State Park since 2017 (when auxiliary bike lanes were first implemented).

3.3.2.5 User Experience

Afterwards, respondents were asked about their experience as a roadway user corresponding to the perspective of the survey. These questions focused on general travel behaviors and habits. Next, drivers and cyclists were asked about their experience as a roadway user of the opposite perspective. This was intentionally designed to generate a new variable and subsequent comparisons between *non-cycling* and *cycling* drivers, and *non-driving* and *driving* cyclists.

3.3.2.6 Remaining Questions

Following, five demographic questions were asked to obtain participants' age, gender, level of education, average household income, and race(s)/ethnicity(s). Respondents were then prompted with the opportunity and designated space (open text boxes) to submit any questions, comments, or recommendations. As incentivized at the beginning of the survey, respondents were then given the opportunity to enter an email address for a chance to win the $50 Amazon gift card.

4.0 RESULTS

In the following chapter, the quality of data and results from each survey are presented and discussed. First, the usable samples for each survey are defined. Secondly, the ODOT Region-level subsamples are compared against the target quotas. Following, the results from each survey are presented by scenario and question type. Under each question type, the results are separated by user and consecutively presented; however, data from the Likert scale questions, regarding level of comfort, will be presented in a combined plot. It should be noted that due to the nature of inductive coding, portions of this methodology are introduced in parallel with the results.

4.1 DATA QUALITY

For each survey, the sample size of completed responses exceeded the target sample sizes (n=300). The data was assessed to identify and remove any gibberish responses. Once removed, these datasets were finalized and used for analysis, as shown in Table 4.1.

Table 4.1: Usable Sample Sizes

	Driver Survey	Cyclist Survey
Initial Sample	311	314
Excluded Responses	6	7
Final Sample	305	307

The ODOT Region quotas were met, with marginal error. In Table 4.2, the actual sample sizes per region are compared with the corresponding target sample size. In each survey, the usable Region 1 sample sizes had the greatest difference from their target sample size. Interestingly, in both surveys, the majority of excluded responses came from Clackamas and Multnomah counties, both of which are in Region 1. For the driver survey, six responses from Region 1 were excluded (Clackamas=4, Multnomah=2). Adjacently, four Region 1 responses were excluded from the cyclist survey (Clackamas=3, Multnomah=1).

Table 4.2: Sample Sizes by ODOT Region

ODOT Region	Target	Driver Survey	Cyclist Survey
1	110	108	104
2	115	119	118
3	36	39	38
4	26	27	33
5	13	12	14

4.2 DEMOGRAPHICS

Table 4.3 presents the distribution of ages and genders for each survey. Overall, the average ages for the driver and cyclist survey were 49.8 (SD=17.6) and 41.6 (SD=14.4), respectively). In both surveys, the gender split was skewed towards females (Female Drivers=55.7%; Female Cyclists=54.4%). In the driver survey, the average age of both the female and male respondents was 50.1 years (SD_{Female}=17.5, SD_{Male}=17.7).

Table 4.3: Age and Gender Distribution (Driver and Cyclist Samples)

DRIVERS	Female	Male	Non-binary	Transgender	PNTA
Count	170	132	1	0	2
Average Age	50.1	50.1	27	-	37.5
Std. Dev.	17.5	17.7	-	-	7.8
Variance	306.5	312.7	-	-	60.5
CYCLISTS	**Female**	**Male**	**Non-binary**	**Transgender**	**PNTA**
Count	167	127	8	1	3
Average Age	41.4	43.0	29.3	18	29.7
Std. Dev.	13.3	15.6	10	-	5.9
Variance	176.0	243.4	99.9	-	34.3

*PNTA: Prefer not to answer

Table 4.4 presents the demographic information for the driver and cyclist survey. As previously mentioned, samples were slightly skewed towards the female gender in both surveys. The age distribution of drivers is spread relatively evenly, with a slight underrepresentation of persons of 18-24 and 75+ years. The cyclist survey age distribution was biased towards persons ages 35 to 44 (n=92, 30%). Persons who were 75 or older were underrepresented (n=2, 0.7%). In both surveys, the majority surveyed ethnicity was White or Caucasian with relatively close sample sizes ($n_{Drivers,W/C+}$=265 and $n_{Cyclists,W/C+}$=266). Of these drivers, 95% (n=251) identified as only being White or Caucasian. The same overrepresentation of White or Caucasians was observed among cyclists with 94% (n=249) identifying only as White or Caucasian. In both surveys, the predominant average household income was between $25,000 and $49,999. Furthermore, 75.9% (n=232) and 72.7% (n=223) of the driver and cyclist samples reported to have an average household income less than $75,000, respectively.

Table 4.4: Demographics (Driver and Cyclist Samples)

Demographic	Classification	Driver Survey (N=305)		Cyclist Survey (N=307)	
		Count	Percentage	Count	Percentage
Gender	Female	170	55.7%	167	54.4%
	Male	132	43.3%	128	42.1%
	Non-binary	1	0.3%	8	2.6%
	Transgender	0	0%	1	0.3%
	Prefer not to answer	2	0.7%	3	0.9%
Age	18-24	29	9.5%	46	15.0%
	25-34	42	13.8%	56	18.2%
	35-44	59	19.3%	92	30.0%
	45-54	38	12.5%	47	15.3%
	55-64	56	18.4%	40	13.0%
	65-74	56	18.4%	24	7.8%
	75+	25	8.2%	2	0.7%
Race (Can be 1 or more)	American Indian/Native American or Alaska Native	15	4.9%	14	4.6%
	Asian	9	3.0%	3	1.0%
	Black or African American	10	3.3%	15	4.9%
	Native Hawaiian or Other Pacific Islander	2	0.7%	2	0.6%
	White or Caucasian	265	86.9%	266	86.6%
	Other	13	4.3%	13	4.2%
	Prefer not to say	7	2.3%	4	1.3%
Income	Less than $25,000	63	20.6%	80	26.1%
	$25,000-$49,999	106	34.6%	82	26.7%
	$50,000-$74,999	63	20.7%	61	19.9%
	$75,000-$99,999	21	6.9%	28	9.1%
	$100,000-$149,999	24	7.9%	24	7.8%
	$150,000 or more	11	3.6%	13	4.2%
	Prefer not to say	17	5.6%	19	6.2%
Education	Some high school or less	11	3.6%	23	7.5%
	High school diploma or GED	65	21.3%	80	26.1%
	Some college, but no degree	102	33.4%	106	34.5%
	Associates or technical degree	40	13.1%	29	9.4%
	Bachelor's degree	61	20.0%	45	14.7%
	Graduate or professional degree	24	7.9%	19	6.2%
	Prefer not to say	2	0.7%	5	1.6%

4.3 EXPERIENCE AS A ROADWAY USER

4.3.1 Motorist Sample

Table 4.5 provides a summary of drivers' habits and experience as a driver and cyclist, if applicable. On average, respondents came into the survey with 22.8 years of driving experience (SD=17.0 years). Most respondents reported to drive frequently, where 92.8% (n=283) of the sample drove at least every week, with the majority driving at least every day (n=176, 57.7%). About one third (n=118, 38.7%) of the drivers reported to routinely drive in rural roadway environments, where the roads are most similar to that of the one in the survey. Lastly, it is important to draw attention to drivers who identified as an active cyclist (n=71, 23.3%) with the remaining drivers considered non-cycling drivers (n=234, 76.7%).

Table 4.5: Experience as a Roadway User (Driver Sample)

DRIVING EXPERIENCE		**Count**	**Percentage (%)**
Frequency of Use	At least every day	176	57.7
	At least every week	107	35.1
	At least every month	12	3.9
	Less than once a month	10	3.3
Routine Environment Type(s)	City/Urban	152	49.8
	Suburban	128	42.0
	Rural	118	38.7
Primary Mode	Car	290	95.1
	Bike	0	0
	Public transit (bus, rail, etc.)	8	2.6
	Walking	5	1.6
	Other (scooter, Uber/Lyft, etc.)	2	0.7
Years of Experience	**Average**	**Standard Deviation**	**Variance**
	22.8	17.0	288.5
CYCLING EXPERIENCE		**Count**	**Percentage (%)**
Cyclists (Active)	Yes (Cycling motorist)	71	23.3
	No (Non-cycling motorist)	234	76.7
Frequency of Use (Bicycle) *n=71	At least every day	9	12.7
	At least every month	22	31.0
	At least every week	33	46.5
	Less than once a month	7	9.9
Type of Cyclist (Geller Scale) n=305	Strong and Fearless	20	6.6
	Enthused and Confident	59	19.3
	Interested but Concerned	107	35.1
	No Way, No How	119	39.0

4.3.2 Cyclist Sample

As shown in Table 4.6, the cyclist sample predominantly consisted of cyclists who self-identified as *Enthused but Confident* on the Geller Scale (n=135; 44.0%) and *Interested but Concerned* (n=118, 38.4%). The majority of the cyclists reported to ride at least every week (n=202, 65.8%), where 15.6% (n=48) of those reported to ride at least every day. About one third (n=116, 37.8%) of the cyclists routinely bike in rural roadway environments, where the roads are most similar to that of the one in the survey. Regarding the respondents' experience as cyclists, most respondents have had 10 or more years of experience (n=151, 49.2%). As opposed to these experienced cyclists, new cyclists made up 5.2% of the sample (n=16).

Of relevance is the subsample of cycling drivers – 81.4% of the cyclists also identified as an active driver (n=250), where 71.9% of these reported to drive at least every week (n=221). As expected, 58% of these frequently driving cyclists were *Strong and Fearless* or *Enthused and Confident* cyclists ($n_{\text{Strong and Fearless}}$=32 and $n_{\text{Enthused and Confident}}$=96).

Table 4.6: Experience as a Roadway User (Cyclist Sample)

CYCLING EXPERIENCE		Count	Percentage (%)
Type of Cyclist (Geller Scale)	Strong and Fearless	45	14.7
	Enthused and Confident	135	44.0
	Interested but Concerned	118	38.4
	No Way, No How	9	2.9
Cycling Purpose(s)	Exercise/Sport	145	47.2
	Recreation	193	62.9
	Travel/Commuting/Errands	98	31.9
Frequency of Use	At least every day	48	15.6
	At least every wseek	154	50.2
	At least every month	71	23.1
	Less than once a month	34	11.1
Years of Experience	<1 year	16	5.2
	1-5 years	77	25.1
	5-10 years	63	20.5
	More than 10 years	151	49.2
Routine Environment Type(s)	City/Urban	135	44.0
	Suburban	138	45.0
	Rural	116	37.8
Primary Mode	Car	194	63.2
	Bike	53	17.3
	Public transit (bus, rail, etc.)	32	10.4
	Walking	22	7.2
	Other (scooter, Uber/Lyft, etc.)	6	2.0
DRIVING EXPERIENCE		**Count**	**Percentage (%)**
Drivers (Active)	Yes (Driving cyclist)	250	81.4
	No (Non-driving cyclist)	57	18.6
Frequency of Car Use *n=250	At least every day	130	42.3
	At least every week	91	29.6
	At least every month	20	6.5
	Less than once a month	9	2.9

4.4 SCENARIO 1 – BASELINE

This scenario was representative of the baseline conditions where the user is driving or biking up the segment of interest with no other roadway users present.

4.4.1 Level of Comfort

In these videos, drivers and cyclists watched a POV-video biking or driving up a two-lane curve with limited visibility and no shoulder or bike lane. In response to the video, the majority of drivers and cyclists both exhibited comfortable experiences (*extremely comfortable* and *somewhat comfortable* combined). Figure 4.1 shows the distribution of responses, by user type, as percentages of the corresponding sample size.

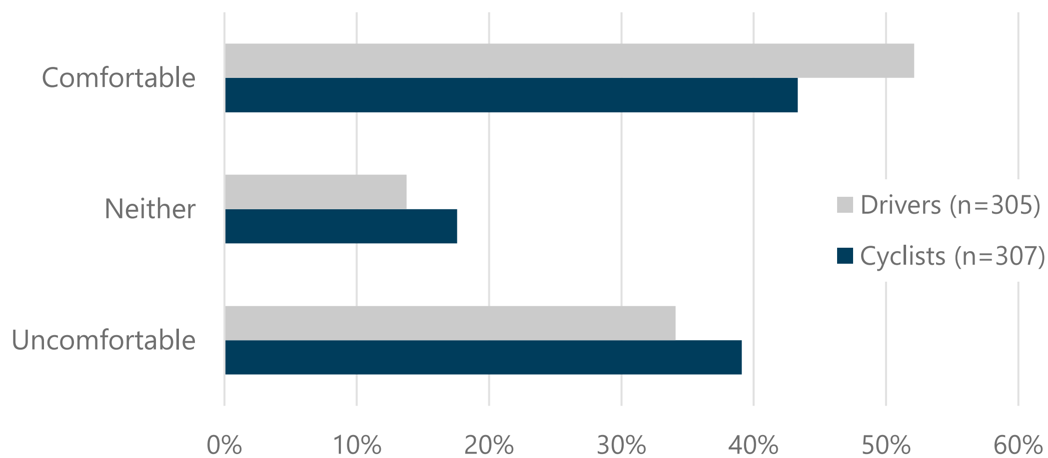


Figure 4.1: Level of Comfort in Response to POV Video (Driver, Scenario 1)

As shown in Table 4.7, a greater proportion of cyclists experienced discomfort while watching the video representing baseline conditions. This is likely a result of experienced-based anticipatory anxiety, as many of the cyclists reported in the corresponding open-ended responses that they were 'waiting' for the driver to appear.

Table 4.7: Level of Comfort: Response to POV Video (Drivers and Cyclists, Scenario 1)

Level of Comfort	Drivers (n=305)	Cyclists (n=307)
Extremely comfortable	72 (23.6%)	52 (16.9%)
Somewhat comfortable	87 (28.5%)	81 (26.4%)
Neither	42 (13.8%)	54 (17.6%)
Somewhat uncomfortable	81 (26.6%)	95 (30.9%)
Extremely uncomfortable	23 (7.5%)	25 (8.1%)

Drivers were asked about their familiarity with the roadway as shown in the video and as described in the introductory prompt. Figure 4.2 shows the proportional distribution of reported levels of comfort by users of both degrees of familiarity. Very similar percentages of unfamiliar and familiar drivers exhibited comfort. Not surprisingly, users familiar with such roads do not experience as much discomfort as those who are unfamiliar.

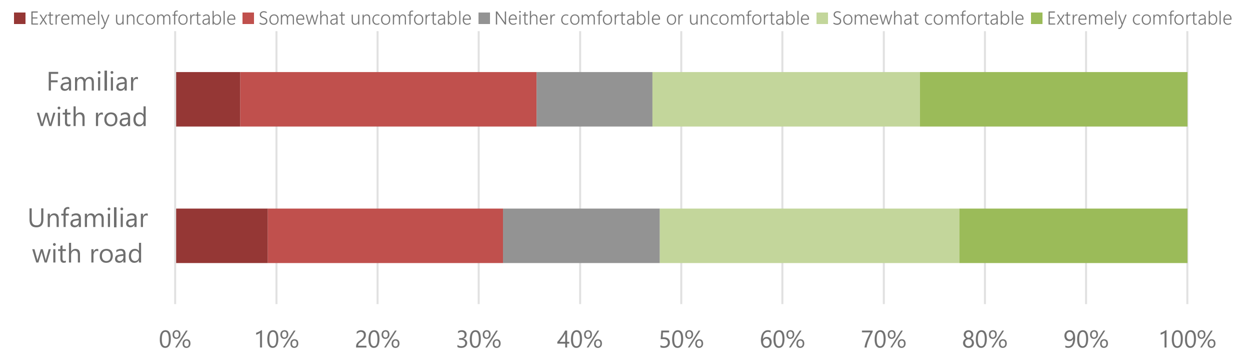


Figure 4.2: Level of Comfort in Response to POV Video, by Familiarity with Roadway (Driver, Scenario 1)

Reported levels of comfort with respect to the type of self-identified Geller cyclist is shown in Figure 4.3. The spread of No Way, No How cyclists is relatively proportional to that of the Interested but Concerned cyclists, with an apparent lateral shift towards discomfort. Moreover, both *Interested but Concerned* and *No Way, No How* cyclist subsamples experienced similar percentages of discomfort where the degrees of discomfort are nearly inversed. Similarly, this is also observed in reported degrees of comfort among the *Enthused and Confident* and *Strong and Fearless* cyclists.

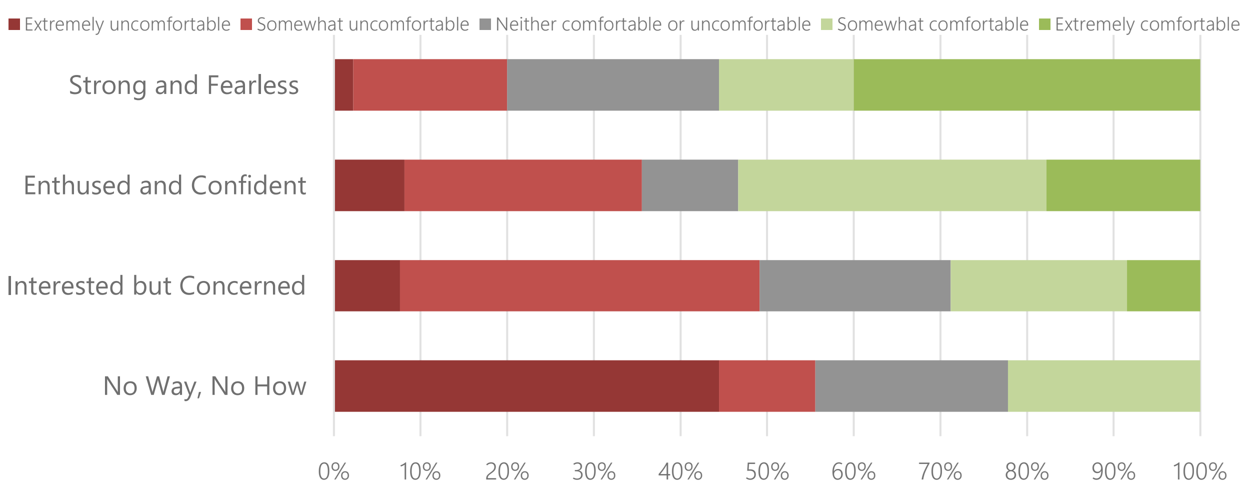


Figure 4.3: Level of Comfort in Response to POV Video, by Geller Cyclist Type (Cyclist, Scenario 1)

4.4.2 Open-Ended Responses (OER)

4.4.2.1 Driver Survey

After assessing responses for common themes, most responses captured participants' sentiment towards the baseline scenario and hence a formal sentiment analysis was conducted. These code values included positive, neutral, negative, and non-sequitur (NSQ). All NSQ responses were removed from the sample upon proceeding with the sentiment analysis and hence, the usable sample size was equal to the full sample (n=305) minus the NSQ sample size. As shown in Table 4.8, 10 responses were non-sequitur, yielding a usable OER sample size of n_{OER}=295.

Table 4.8: Open-Ended Response Sample Size (Driver, Scenario 1)

Sample	Sample Size
Full Sample ($n_{drivers}$)	305
NSQ (n_{NSQ})	10
Usable OER Sample (n_{OER})	295

As previously mentioned, a sentiment analysis was performed on this sample, where responses were coded as positive, neutral, negative, and non-sequitur. Each code value is presented in Table 14. These open-ended responses were further assessed using aspect-based sentiment analysis. Considering this scenario was representative of baseline conditions, responses were not as exploratory as those of Scenarios 2 and 3. From this, a significant subsample of participants were found to have stated their orientation of comfort as either uncomfortable or comfortable, respectively yielding the creation of two mutually exclusive codes, which are also defined in Table 4.9.

Table 4.9: Open-Ended Response Coding (Driver, Scenario 1)

	Code Value	Criteria
SENTIMENT ANALYSIS	Positive	**Definition:** Any response that explicitly states, indicates via synonymous verbiage, or implies positive sentiment regarding driving on the segment of interest. **Keywords:** good, great, confident, enjoyable, fun, like/love it **Example:** "I feel confident driving on this type of 2-lane road.", "Good", "Confident and careful"
	Neutral	**Definition:** Any response that explicitly states, indicates via synonymous verbiage, or implies positive sentiment. **Keywords:** fine, don't mind, okay **Example:** "I don't mind driving on these kind of roads", "Just be careful.", "I take it easy."
	Negative	**Definition:** Any response that explicitly states, indicates via synonymous verbiage, or implies negative sentiment regarding driving on the segment of interest. **Keywords:** dangerous, scary, nervous, frustrated, dislike, hate **Example:** "Scared [and] anxious", "I would feel claustrophobic and scared", "Its a little unsettling"
	Comfortable	**Definition:** Any response that explicitly states, indicates via synonymous verbiage, or implies a degree of comfort. **Keywords:** confident, great, fine, not a problem **Example:** "I feel calm and comfortable on roads of this manner." **Example:** "I feel confident, and I stay alert."
	Uncomfortable	**Definition:** Any response that explicitly states, indicates via synonymous verbiage, or implies a degree of discomfort or opposition to comfort. **Keywords:** scared, nervous, anxious, worried **Example:** "A little uncomfortable because it is so tight there is not much room for mistakes or comfort", "Uneasy", "Not secure"

The results from the sentiment analysis are visualized in Figure 4.4. Generally, drivers described their experiences driving on roads, similar to that of the video, to vary across degrees, with the largest subsample (n=120) indicating negative sentiment.

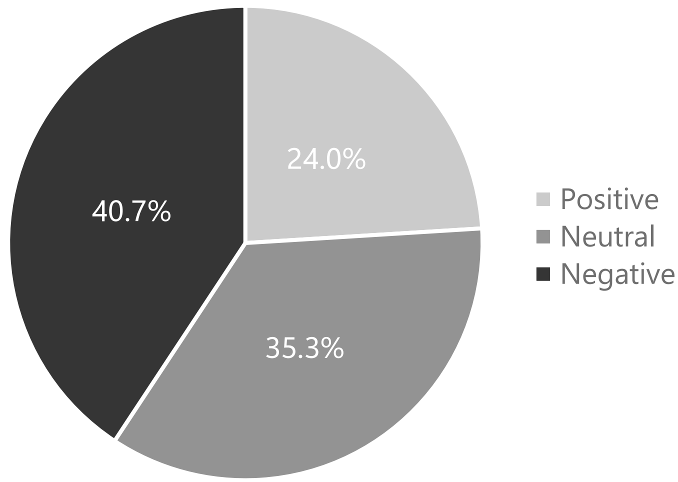


Figure 4.4: Sentiment Analysis, n=295 (Driver, Scenario 1)

In addition to the sentiment analysis, the aspect analysis showed that 116 (38.9%) experience discomfort when driving along "tight curves with limited visibility on a 2-lane road with no median, shoulder, or bike lane". Whereas 102 (34.2%) drivers indicated to exhibit some degree of comfort. Recalling the conditions of aspect analyses and their independent assessments, these subsamples cannot be summed together as there are OER that were inapplicable to these aspects.

4.4.2.2 Cyclist Survey

The cyclists' OERs to the baseline condition did not warrant a sentiment analysis, instead, most responses centered around respondents' level of comfort with the road segment of interest. Correspondingly, a topic analysis was performed with respect to user comfort as the topic. These code values included comfortable, neutral, uncomfortable, inconclusive, and non-sequitur (NSQ). All NSQ responses were removed from the sample upon proceeding with the sentiment analysis, where the resulting usable sample size, n_{OER}, is shown in Table 4.10.

Table 4.10: Open-Ended Response Sample Size (Cyclist, Scenario 1)

Sample	Sample Size
Full Sample ($n_{drivers}$)	307
NSQ (n_{NSQ})	15
Usable OER Sample (n_{OER})	292

In Table 4.11, the four code values are defined and outlined with examples responses from the survey. All responses in the OER sample were assigned one of the following codes.

Table 4.11: Open-Ended Response Coding (Cyclist, Scenario 1)

Code	Criteria
Comfortable	**Definition:** Any response that explicitly states, indicates via synonymous verbiage, or implies a degree of comfort. **Keywords:** confident, great, not worried, like, love **Example:** "Not too far worried about it", "I just feel comfortable", "Comfort and enjoy the beautiful scenery", "Alright no real concerns or worries"
Neutral	**Definition:** Any response that does not explicitly state, indicate via synonymous verbiage, or imply a level of comfort or discomfort. **Keywords:** fine, don't mind, okay **Example:** "I usually stay very near to the right with caution", "I think it was somewhat safe", "I'd feel a little sketchy, but overall fine"
Uncomfortable	**Definition:** Any response that explicitly states, indicates via synonymous verbiage, or implies a degree of discomfort or opposition to comfort. **Keywords:** scared, nervous, anxious, worried **Example:** "Worried someone will come around a curve to fast and not see me in time", "It is highly dangerous"," It makes me feel nervous and uncomfortable I am constantly watching for vehicles while cycling."
Inconclusive	**Definition:** Any response that either indicates uncertainty or does not exclusively meet the criteria of the above three code values but is sequitur. **Example:** "I don't know", "Glad to make it around the corner with no vehicles"

Figure 4.5 shows the spread of levels of comfort. When compared to the levels of comfort in response to watching the video, more participants exhibited discomfort when asked about their experience-based perspective ($n_{Likert,Uncomfortable}$=39.0% vs. $n_{OER,Uncomfortable}$=55%). This means that the video did not induce the same feelings of discomfort or induce discomfort to a lesser degree than what is experienced on the roadway. First, some of the discrepancies are due to the difference in simulated versus real-world experiences, as video-based perspectives cannot fully represent and replicate the feelings associated with the real-world experience. Secondly, this discrepancy could be due to the environmental conditions of the roadway in the video. The roadway in the video may be different than the two-lane, limited visibility roadways that the participants are familiar with, examples being the lighting, lane width, ditch/drop-off design, etc. If the simulated conditions cue more comfortable feelings, such as a perceived wider lane, this will be reflected by a difference in reported levels of comfort.

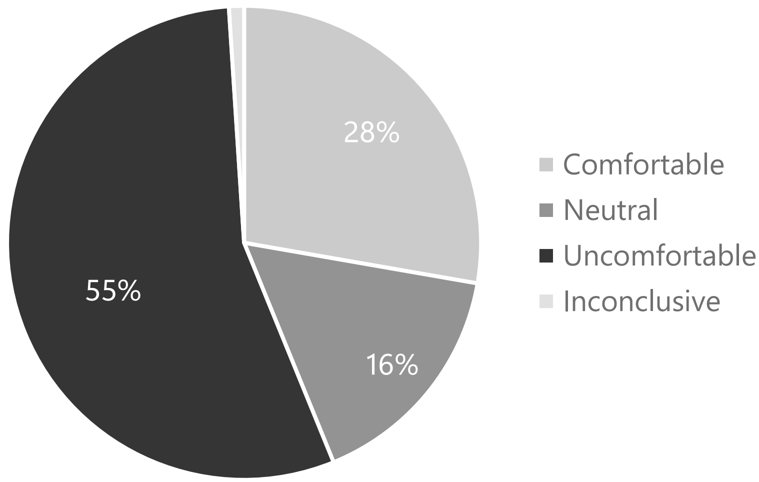


Figure 4.5: Aspect Analysis, Degree of Comfort, n=292 (Cyclist, Scenario 1)

4.5 SCENARIO 2 – EXISTING CONDITIONS (OVERTAKE)

This scenario was representative of the existing conditions where a driver is following a cyclist on the segment of interest and then temporarily enters the opposing travel lane to overtake (pass) the cyclist.

4.5.1 Level of Comfort

Figure 4.6 shows the distribution of drivers' and cyclists' levels of comfort in response to their POV video of the vehicle-overtaking-cyclist maneuver. For both user perspectives, the majority level of comfort was *somewhat uncomfortable*. As opposed to the drivers, there is more spread between cyclists' level of comfort. The corresponding data values are provided in Table 4.12

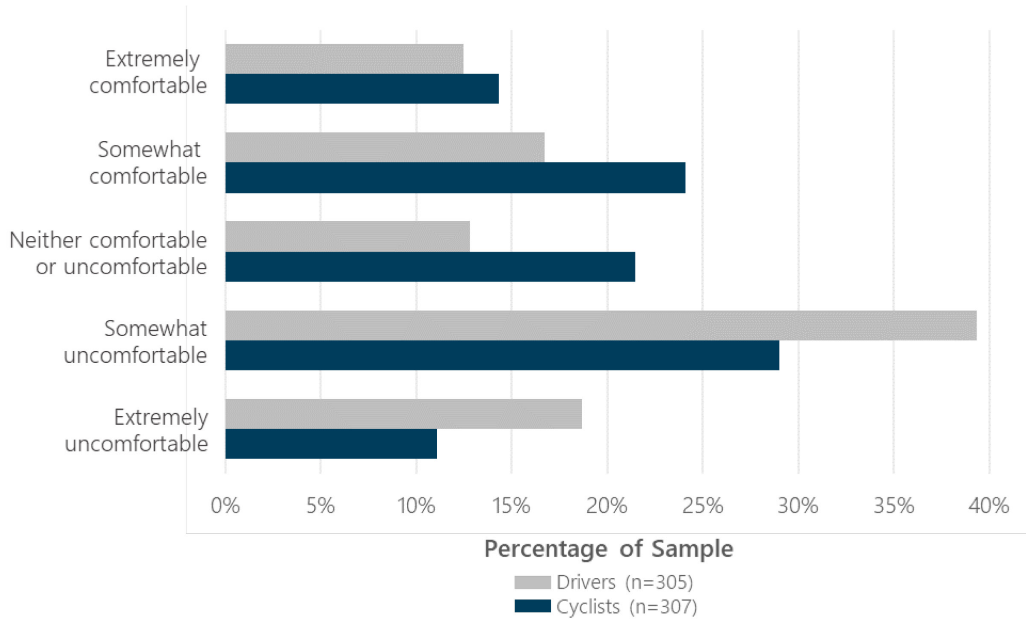


Figure 4.6: Level of Comfort in Response to Video (Driver and Cyclist, Scenario 2)

Table 4.12: Level of Comfort: Response to POV Video (Drivers and Cyclists, Scenario 2)

Level of Comfort	Drivers (n=305)	Cyclists (n=307)
Extremely comfortable	38 (12.5%)	44 (14.3%)
Somewhat comfortable	51 (16.7%)	74 (24.1%)
Neither	39 (12.8%)	66 (21.5%)
Somewhat uncomfortable	120 (39.3%)	89 (29.0%)
Extremely uncomfortable	57 (18.7%)	34 (11.1%)

Interestingly, the two most predominant comfort levels with the experience of a vehicle overtaking a cyclist differed between drivers and cyclists – drivers mostly reported to be either somewhat or extremely uncomfortable, whereas most cyclists exhibited opposing degrees of comfort. Considering cyclists' vulnerability while being overtaken, it is noteworthy to observe that 24% of cyclists reported to be somewhat comfortable and 29% of cyclists reported to be somewhat uncomfortable.

Table 4.13: Cyclists' Level of Comfort with Being Overtaken by Vehicles

Level of Comfort	Cyclists (n=307)
Extremely comfortable	21 (6.9%)
Somewhat comfortable	35 (11.5%)
Neither	51 (16.7%)
Somewhat uncomfortable	108 (35.4%)
Extremely uncomfortable	92 (30.2%)

When asked their level of comfort with being overtaken, 35.4% and 30.2% of cyclists reported to be somewhat and extremely uncomfortable, respectively (Table 4.13). As opposed to 65.6%

indicating discomfort, only 18.4% indicated degrees of comfort with being overtaken. When compared to the levels of comfort in response to watching the POV, these generalized levels of comfort describe a population of cyclists with greater levels of discomfort. The discrepancy between each can likely be attributed to the degree of separation that is imposed by the POV video, which is difficult to compare to a generalized level of comfort that is derived from actual experiences of being overtaken.

4.5.2 Open-Ended Responses

4.5.2.1 Driver Survey

An overall assessment of drivers' OERs to the existing conditions did not warrant sentiment analysis. Rather, an aspect analysis was determined more feasible. The primary aspect, which was observed in the majority of responses, was the respondent's willingness to overtake a cyclist, as the driver did in the POV video. These code values included will overtake, may or may not overtake, will not overtake, unsure/inconclusive, and non-sequitur (NSQ). Before proceeding, non-sequitur responses (n_{NSQ}=6) were removed from the full sample (n=305) and hence, the resulting sample sized used in the OER analysis equated to n_{OER}=299, as shown in Table 4.14.

Table 4.14: Open-Ended Response Sample Size (Driver, Scenario 2)

Sample	Sample Size
Full Sample ($n_{drivers}$)	305
NSQ (n_{NSQ})	6
Usable OER Sample (n_{OER})	299

The code values and definitions corresponding to the *willingness to overtake a cyclist* code are outlined with definitions, keywords, and examples in Table 20. The open-ended responses were further assessed to identify other commonalities and shared aspects between responses. As opposed to the baseline conditions, participants elicited more emotions in their responses and consequently more content, covering multiple aspects. Similarly, more participants provided insight into their feelings towards the existing conditions. Four aspects were observed to be commonly addressed, further warranting an aspect analysis. These four binary aspects were *cautious, comfortable, unsafe, uncomfortable* and are defined in the bottom half of Table 4.15. It is important to note that in opposition to the baseline conditions code, the codes *uncomfortable* and *comfortable* are not mutually exclusive as some responses indicated both degrees of comfort.

Table 4.15: Open-Ended Response Coding (Driver, Scenario 2)

Code Value		Criteria
DISPOSITION TO OVERTAKE	Will overtake	**Definition:** Any response that states, indicates, or implies a disposition and/or capacity to overtake the cyclist as the driver did in the POV video. **Example:** "I would slow way down almost matching the [speed] of the rider until I was pass and then move over", "I'm comfortable making this movement while being observant in oncoming traffic, if any as well as knowing where the cyclist is behind me"
	May or may not overtake	**Definition:** Any response that states, indicates, or implies a conditional willingness or capability to overtake the cyclist as the driver did in the POV video. Most often, these respondents explicitly state the risk or discomfort and then connect it to a contrasting idea that indicates there is some level of comfort with doing so and/or describes how to safely (subjectively) overtake a cyclist. **Example:** "I feel uncomfortable about it a little. I feel like I could do it safely though.", "Somewhat anxious but I try to be very careful and look ahead and around and if it's not clear I will usually turn hazards on in case someone is coming up on me and can't see the cyclist"
	Will not overtake	**Definition:** Any response that states, indicates, or implies an opposition to overtaking the cyclist as the driver did in the POV video. **Example:** "I would not feel comfortable doing so. I would wait till it was safe to pass." "Makes me nervous. I feel scared."
	Inconclusive	**Definition:** Any response that does not meet any criteria for the three code values listed above but still answers the question. **Example:** "Frustrated because [of] the lack of safety precautions for both cyclist and driver"
Binary Codes		**Criteria**
Cautious		**Definition:** Any response that explicitly states, indicates via synonymous verbiage, or implies the act of being cautious or needing to be cautious in the interaction of interest. **Example:** "I am more cautious in this type of driving situation. Better safe than sorry!" **Keywords:** careful, alert, attentive, aware **Example:** "I would stay very alert to oncoming traffic and possibly irrational bike rider." **Keywords:** looking for, anticipating, listening for, watching **Example:** "I watch out and give the cyclists the right of way"
Comfortable		**Definition:** Any response that explicitly states, indicates via synonymous verbiage, or implies a degree of comfort. **Example:** "Very comfortable and safe"

Code Value	Criteria
	Keywords: confident, great, fine, not a problem **Example:** “I feel good about it” **Definition:** Responses that implied comfort were observed and coded correspondingly. These responses typically described how they overtake cyclists. **Example:** “I feel capable of adjusting my speed and look [further] ahead”; “Well again drive slow and [cautiously], and follow the bike at a safe distance behind until you are able to pass safely… I have nothing but time..”
Unsafe	**Definition:** Any response that explicitly states, indicates via synonymous verbiage, or implies the overtaking of a cyclist on the segment of interest is unsafe. **Example:** “Irresponsible and unsafe” **Keywords:** dangerous, risky **Example:** “Extremely cautious. This is a dangerous situation” **Keywords:** accident, hit cyclist, wreck, crash **Example:** “Very nervous that there might be an oncoming car and there might be a wreck”
Uncomfortable	**Definition:** Any response that explicitly states, indicates via synonymous verbiage, or implies a degree of discomfort or opposition to comfort. **Example:** “Uncomfortable and I feel like the bicyclist would also feel pressure to go faster” **Keywords:** scared, nervous, anxious, worried **Example:** “Nervous, anxious tense” Responses that implied discomfort typically described their opposition to overtaking a cyclist or the behavior of the driver in the POV video. **Example:** “I won’t do that”

Proceeding with the n_{OER}, drivers' willingness to overtake a cyclist on the segment of interest are visualized in Figure 4.7.

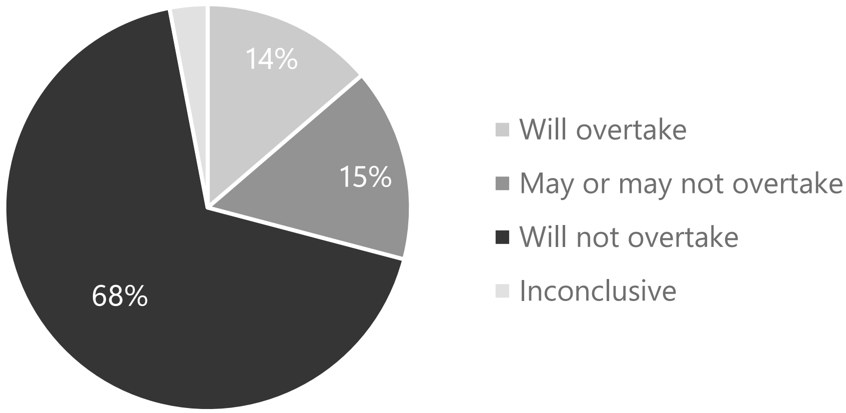


Figure 4.7: Aspect Analysis, Willingness to Overtake, n=299 (Driver, Scenario 2)

When asked how drivers felt about "passing a cyclist along a tight curve with limited visibility on a 2-lane road with no median, shoulder, or bike lane", 55.5% of drivers indicated some discomfort. It is important to note that the presence of discomfort is not necessarily related to if the driver passes a cyclist. There was a subsample of drivers who implied comfort with the overtaking of a cyclist and also indicated that discomfort is present but correspondingly, their level of awareness and caution are heightened.

4.5.2.2 Cyclist Survey

After assessing the cyclists' open-ended responses, there was a percentage of responses that were not explicit enough to conclude their respective sentiment. Consequently, a sentiment analysis was not conducted. Instead, an aspect analysis of cyclists' comfort/discomfort was deemed more suitable as most responses indicated whether the cyclist was comfortable, neutral, or comfortable with being overtaken. Before proceeding with this analysis, all NSQ responses (n_{NSQ}=12) were removed from the sample, yielding a usable sample size to n_{OER}=299, as shown in Table 4.16.

Table 4.16: Open-Ended Response Sample Size (Cyclist, Scenario 2)

Sample	Sample Size
Full Sample ($n_{drivers}$)	307
NSQ (n_{NSQ})	12
Usable OER Sample (n_{OER})	295

Like the driver survey responses, cyclist responses exhibited greater magnitudes of emotions, nonetheless, more cyclists chose to respond with more information as opposed to Scenario 1. Given the depth of content, an aspect analysis was deemed suitable, where the inductively created binary codes are *discomfort, tolerant/complacent,* and *comfortable/confident.* It is important to note that only the last two codes are mutually exclusive. Respondents who did not indicate discomfort exclusively were observed to indicate various degrees of comfort. Following a thorough assessment to determine ways to differentiate and categorize these responses, responses were observed to either indicated a degree of complacency and tolerance with being overtaken or indicated no level of opposition to being overtaken, commonly summarized by confidence and explicit comfort. These three codes and their respective criteria are outlined in Table 4.17, with example survey responses.

Table 4.17: Open-Ended Response Coding (Cyclist, Scenario 2)

Binary Code	Criteria
Uncomfortable	**Definition:** Any response that explicitly states, indicates via synonymous verbiage, or implies a degree of discomfort or opposition to comfort. **Keywords** *scared, nervous, anxious, worried* **Example:** "That would make me uncomfortable having no shoulder to protect from the traffic", "I feel uneasy. I am terrified. I cannot see behind me and hope and pray someone doesn't come from the front also."
Comfortable to Confident	**Definition:** Any response that explicitly states, indicates via synonymous verbiage, or implies a degree of comfort and or confidence. Synonymous verbiage – keywords and action phrases – include any form of the following: confident, great, fine, not a problem **Example:** "Confident, I've been riding a long time.", "Easy to use". "
Tolerant and Complacent	**Definition:** Any response that does not meet the criteria of *Comfortable to Confident* but explicitly states, indicates via synonymous verbiage, or implies a degree of complacency with being overtaken. Typically, this was observed by respondents explaining what they strategically do when there are drivers approaching that may overtake them. **Example:** "I don't mind as I pay attention", "I'm used to it and so I don't feel much about it. However, it would be easier if there was a bicycle lane option."

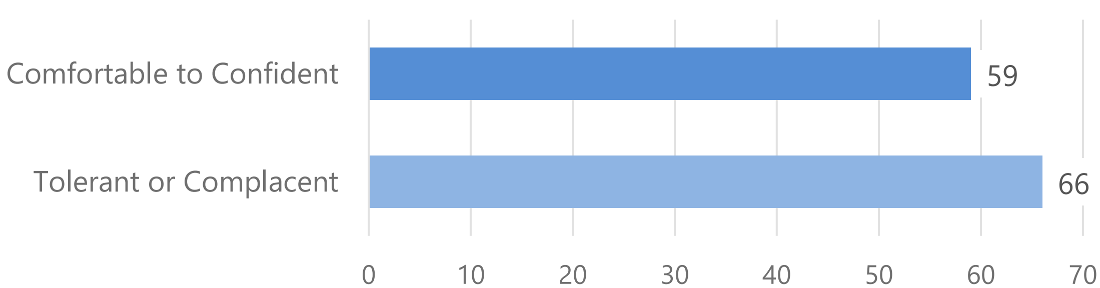


Figure 4.8: Aspect Analysis, Tolerant or Complacent and Comfortable-to-Confident (Cyclist, Scenario 2)

The results from the aspect analysis of cyclists' open-ended responses to how they felt about being overtaken by a driver are shown in Figure 4.8. To some degree, these result validate the cyclists' perception of comfort who said they were *somewhat* and *extremely comfortable*, where the *Comfortable to Confident* cyclists corresponds to cyclists with extreme levels of comfort ($n_{OER,\text{Comfortable and Confident}}$=59 vs. $n_{\text{Likert,Extremely comfortable}}$=44) and *Tolerant or Complacent* cyclists corresponds to cyclists with somewhat comfort ($n_{OER,\text{Tolerant and Complacent}}$=66 vs. $n_{\text{Likert,Somewhat comfortable}}$=74). The number of cyclists who were coded with *Uncomfortable* is not shown, as it is not mutually exclusive to the second and third code; however, this number of respondents was like that of the driver's sample (n=161, 54.6%).

4.6 SCENARIO 3 – PROPOSED CONDITIONS (BIKE TURNOUT)

4.6.1 Level of Comfort

After experiencing the auxiliary bike lanes through their POV video, drivers, and cyclists both reacted with strong levels of comfort, as opposed to that of the existing conditions. Moreover, levels of discomfort were less than those of the baseline conditions. This is visualized in Figure 4.9 with the corresponding data values provided in Table 4.18.

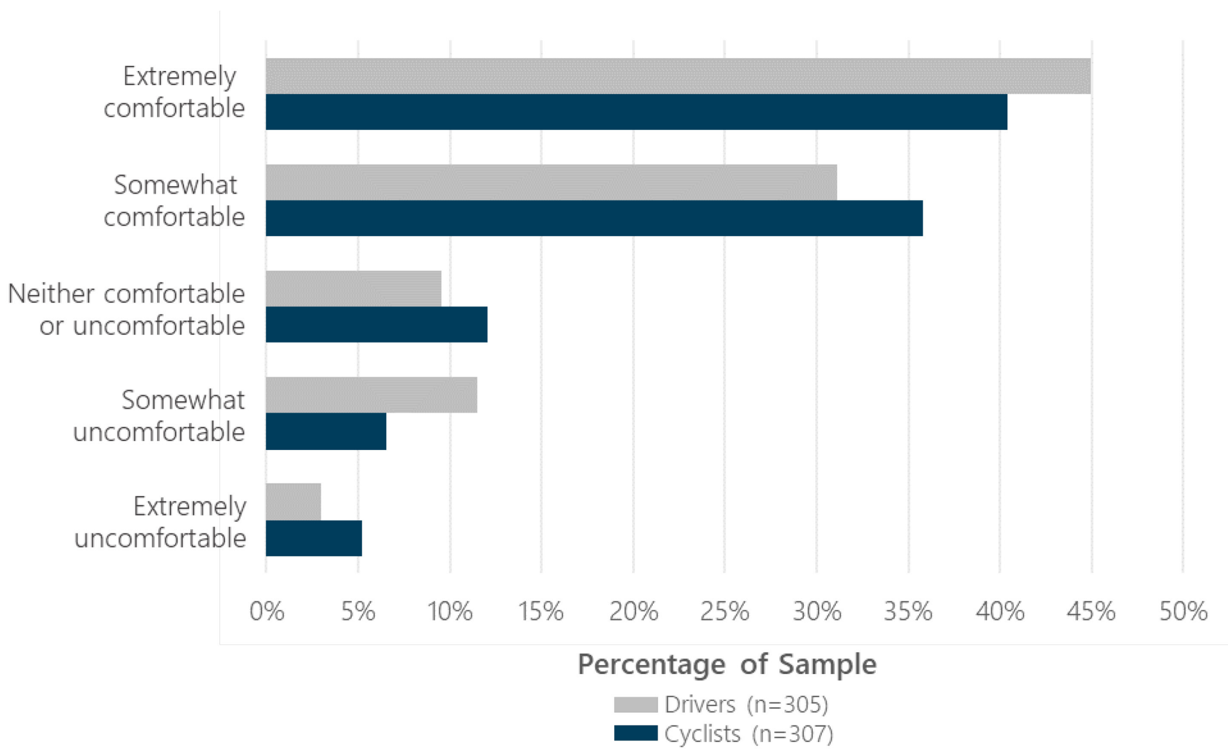


Figure 4.9 - Level of Comfort in Response to POV Video (Driver and Cyclist, Scenario 3)

Table 4.18: Level of Comfort: Response to POV Video (Drivers and Cyclists, Scenario 3)

Level of Comfort	Drivers (n=305)	Cyclists (n=307)
Extremely comfortable	137 (44.9%)	124 (40.4%)
Somewhat comfortable	95 (31.1%)	110 (35.8%)
Neither	29 (9.5%)	37 (12.1%)
Somewhat uncomfortable	35 (11.5%)	20 (6.5%)
Extremely uncomfortable	9 (3.0%)	16 (5.2%)

4.6.2 Open-Ended Responses

4.6.2.1 Driver Survey

After assessing responses for common themes, most responses captured participants' sentiment towards the proposed conditions and hence a formal sentiment analysis was conducted. Before proceeding, all non-sequitur responses were removed from the sample. As shown in Table 4.19, seven responses were non-sequitur, yielding a usable OER sample size of n_{OER}=298.

Table 4.19: Open-Ended Response Sample Size (Driver, Scenario 3)

Sample	Sample Size
Full Sample ($n_{drivers}$)	305
NSQ (n_{NSQ})	10
Usable OER Sample (n_{OER})	295

A sentiment analysis was performed on this sample with code values of *positive, neutral, negative,* and *inconclusive*, each of which are described with examples in Table 26. The open-ended responses were further assessed to identify other commonalities and shared aspects between responses. Resulting from this preliminary scan was the trend of stating an initial impression and/or elaborating on their feelings towards the concept of bike turnouts. Therefore, the code *receptivity* was defined, with its values defined in Table 4.20.

Table 4.20: Open-Ended Response Coding (Driver, Scenario 3)

	Code Value	Criteria
SENTIMENT	Positive	**Definition:** Any response that explicitly states, indicates via synonymous verbiage, or implies positive sentiment regarding driving on the segment of interest. **Keywords:** *good, great, confident, enjoyable, fun, like/love it* **Example:** "I think in some cases they would be much appreciated, like driving to the coast, they could use some there and in any other curvy slow going roads, make it a little safer for both parties", This is a safe option. I'm all for it, you have my vote",
	Neutral	**Definition:** Any response that is relevant but does not explicitly state, indicate via synonymous verbiage, or imply positive or negative sentiment. These typ **Example:** "The cyclists should have to pay for them, not motorists." "Auxiliary bike lanes probably make the cyclist feel safer, but the turnouts have no bearing on me or my style of driving."
	Negative	**Definition:** Any response that explicitly states, indicates via synonymous verbiage, or implies negative sentiment regarding driving on the segment of interest. **Keywords:** *dangerous, scary, nervous, frustrated, dislike, hate* **Example:** "Another added cost for a few", "Scary"
RECEPTIVITY	Receptive	**Definition:** Any response that explicitly states, indicates via synonymous verbiage, or implies a complete favor towards auxiliary bike lanes or only positive feelings in response to being exposed to bike turnouts. **Example:** "I think this is a good idea because it is safe for the driver and the bike rider. Good idea"
	Potentially Receptive	**Definition:** Any response that exhibits receptivity **but** explicitly states, indicates via synonymous verbiage, or implies concerns or reservations about bike turnouts. **Example:** "It sounds like a good idea, but I wonder how much time and money that we don't have it will cost to implement them."
	Not Receptive	**Definition:** Any response that explicitly states, indicates via synonymous verbiage, or implies a complete favor against auxiliary bike lanes or only negative feelings in response to being exposed to bike turnouts. **Example:** "so few riders not worth expense"," [I] think the turnouts are a good idea, but I do not think the investment is worth it with inflation, crime, guns, and drugs all rampant in Oregon"
	Inconclusive	**Definition:** Any response not sufficient enough to extract the respondent's degree of receptivity. **Example:** "Idk"

Figure 4.10 shows the results from the sentiment analysis of drivers open-ended responses: 90% of respondents (n=270) exhibited positive sentiment when talking about their feelings towards bike turnouts, whereas 4% (n=11) of drivers exhibited negative sentiment.

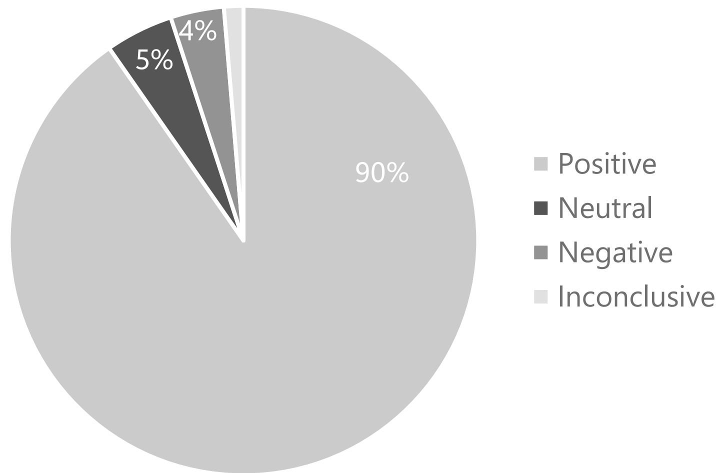


Figure 4.10 - Sentiment Analysis, n=295 (Driver, Scenario 3)

The analysis of drivers' overall receptivity, as captured from just their open-ended responses, yielded the following rates per value of receptivity and corresponds (from left to right) to the samples shown in Figure 4.11 – Receptive: 89.0%; Potentially receptive: 4.0%; Not receptive: 6.0%; Inconclusive: 1%, n=4 (not shown).

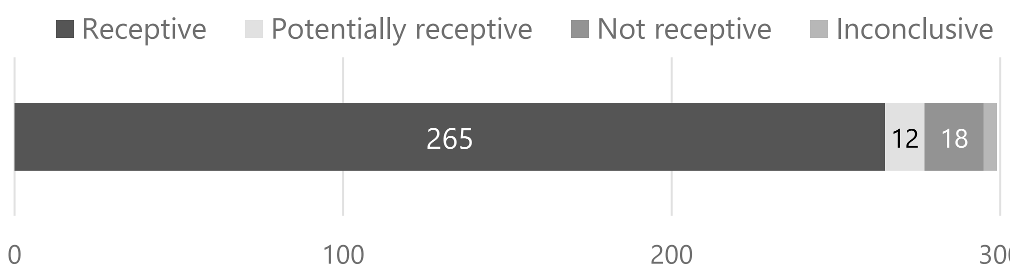


Figure 4.11 - Aspect Analysis, Receptivity to Bike Turnouts, n=299 (Driver, Scenario 3)

4.6.2.2 Cyclist Survey

An overall assessment of cyclists' open-ended responses to the proposed conditions did not warrant sentiment analysis. Before proceeding with further assessments, all non-sequitur responses (n_{NSQ}=5) were identified and removed from the full sample, resulting in the usable sample size, n_{OER}=302, as shown in Table 4.21.

Table 4.21: Open-Ended Response Sample Size (Cyclist, Scenario 3)

Sample	Sample Size
Full Sample ($n_{drivers}$)	307
NSQ (n_{NSQ})	5
Usable OER Sample (n_{OER})	302

After further assessing and comparing responses, all responses were coded for their degree of receptivity to bike turnouts. After further assessing responses, an aspect analysis was performed for two aspects of responses – safety and lingering concerns, as defined in Table 4.22.

Table 4.22: Open-Ended Response Coding (Cyclist, Scenario 3)

	Code Value	Criteria
RECEPTIVITY	Receptive	**Definition:** Any response that explicitly states, indicates via synonymous verbiage, or implies a complete favor towards auxiliary bike lanes or only positive feelings in response to being exposed to bike turnouts. **Example:** "They are needed for safety purposes"
	Potentially Receptive	**Definition:** Any response that exhibits receptivity but explicitly states, indicates via synonymous verbiage, or implies concerns or reservations about bike turnouts. **Example:** "It's a great idea but I worry that vehicles would not wait for the bike turnout to pass.", "Not sure it'll work completely"
	Not Receptive	**Definition:** Any response that explicitly states, indicates via synonymous verbiage, or implies a complete favor against auxiliary bike lanes or only negative feelings in response to being exposed to bike turnouts. **Example:** "I think they would be too expensive"
	Inconclusive	**Definition:** Any response that was not sufficient to extract the respondent's degree of receptivity. **Example:** "It would only help by getting lucky", "How much would it cost?"

Binary Codes	Criteria
Safety	**Definition:** Any response that explicitly states, indicates via synonymous verbiage, or implies auxiliary bike lanes are perceived as safe or would improve the safety of the roadway. **Example:** "I think that makes it 10 times more safe for bikers approaching turns like that, it also makes it safe for cars that are behind you.", "Looks safer for riders and drivers of all demographics"
Lingering Concerns	**Definition:** Any response that includes a degree of positive sentiment but is connected to a contrasting idea that explicitly states, indicates via synonymous verbiage, or implies concerns or reservations about bike turnouts. The intention of this code was to highlight respondents who show favoring of auxiliary bike lanes but have remaining concerns and hence, responses coded as Not Receptive were excluded. **Example:** "It would be revolutionary but also implicate cyclists as cars might start driving recklessly because we have bike turnouts", "It is a great idea in theory but I am worried cars might think they should use it as an emergency shoulder and hit me or other bicyclists and how much it'll cost"

As shown in Figure 4.12, the analysis of cyclists' overall receptivity, as captured from just their open-ended responses, yielded the following results for the 302 OER-sample: Receptive: 87.8%; Potentially receptive: 5.6%; Not receptive: 3.0%; Inconclusive: 3.6%.

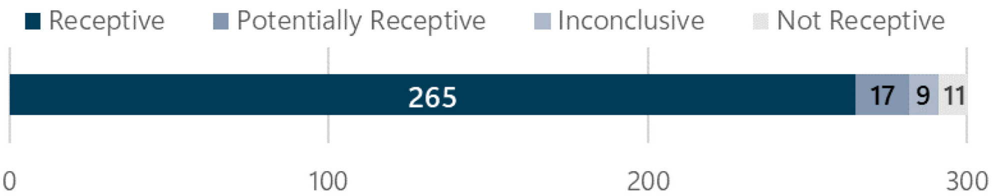


Figure 4.12 - Aspect Analysis, Receptivity, n=302 (Cyclist, Scenario 3)

4.7 USER PERSPECTIVES ASSESSMENT

The results from the 5-point Likert scale questions probing user perceived safety, value, and comfort of auxiliary bike lanes are tabulated in Table 4.23.

Table 4.23: User Perspectives on Safety, Comfort, and Value of Bike Turnouts

How effective do you think auxiliary bike lanes would be in improving your level of comfort when [passing a cyclist / biking along tight curves (vehicles are present)] with limited visibility on a 2-lane road with no median, shoulder, or bike lane?					
	Extremely effective	**Very effective**	**Moderately effective**	**Slightly effective**	**Not at all effective**
Drivers	132 (43.3%)	104 (34.1%)	42 (13.8%)	21 (6.9%)	6 (2.0%)
Cyclists	109 (35.5%)	114 (37.1%)	55 (17.9%)	24 (7.8%)	5 (1.6%)
In general, how valuable do you think it would it be to implement auxiliary bike lanes on tight curves with limited visibility?					
	Extremely valuable	**Very valuable**	**Moderately valuable**	**Slightly valuable**	**Not at all valuable**
Drivers	151 (49.5%)	92 (30.2%)	32 (10.5%)	23 (7.5%)	7 (2.3%)
Cyclists	140 (45.6%)	100 (32.6%)	46 (15.0%)	17 (5.5%)	4 (1.3%)
How effective do you think auxiliary bike lanes would be in reducing potential crashes on tight curves with limited visibility?					
	Extremely effective	**Very effective**	**Moderately effective**	**Slightly effective**	**Not at all effective**
Drivers	137 (44.9%)	95 (31.1%)	48 (15.7%)	19 (6.2%)	6 (2.0%)
Cyclists	113 (36.8%)	117 (37.8%)	51 (16.6%)	20 (6.5%)	7 (2.3%)

A total of 71 drivers reported to be active cyclists, yielding the remaining 234 non-cycling drivers. The corresponding distribution of responses to "*How effective do you think* auxiliary bike lanes *would be in reducing potential crashes on tight curves with limited visibility?"* is shown in Figure 4.13. Cycling drivers indicated the strongest and weakest levels of effectiveness when compared to non-cycling drivers.

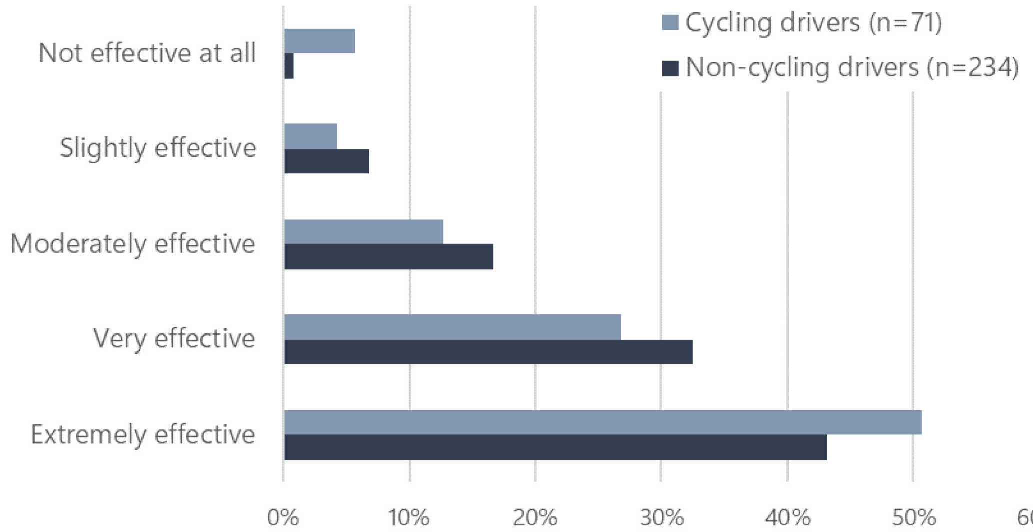


Figure 4.13 - Effectiveness on Reducing Potential Crashes, Cycling vs. Non-Cycling Drivers

Four cycling drivers and two non-cycling drivers perceived the implementation of auxiliary bike lanes would have no effect on reducing crashes. Turning to their open-ended responses provides insight as one non-cycling driver responded about their feelings to the existing conditions with "*My corvette accelerated from q to 60+ miles per hour in less than 3 seconds. As long as there is not oncoming traffic, I have no problem blowing past cyclists*", following the initial exposure to bike turnouts, their response reads "auxiliary bike lanes *probably make the cyclist feel safer, but the turnouts have no bearing on me or my style of driving*." Further, this driver's adjacent responses were "not valuable at all" and "not effective at all", with reference to auxiliary bike lanes improving their level of comfort. Looking towards the open-ended responses of the four cycling drivers, two explicitly indicated that bikers should not be on roads, one commenting at the end of the survey: "*Can we get them removed?*", "*They should not be on roads*", and "*I don't like bike roads*". Collectively, these responses appear to be tied to existing disposition, and subsequent biases, that may have overshadowed their ability to precisely comprehend and objectively respond to the question.

After the second scenario, cyclists were asked if they have ever been overtaken by a vehicle, to which 73.3% (n=225) said 'yes'. Given this sample of cyclists had real-life experience with what was shown in the video and what auxiliary bike lanes remedy, it is of relevance to narrow the focus on these cyclists' perceptions on bike turnouts. As shown in Figure 4.14, the majority of these cyclist indicated the highest levels of effectivity. More specifically, for each question-topic, the majority of these cyclists indicated the *extremely* level: (*extremely effective on improving their level of comfort*, n=88, 39.1%; *extremely valuable*, n=109, 48.4%; *extremely effective in reducing potential crashes*, n=86, 38.2%).

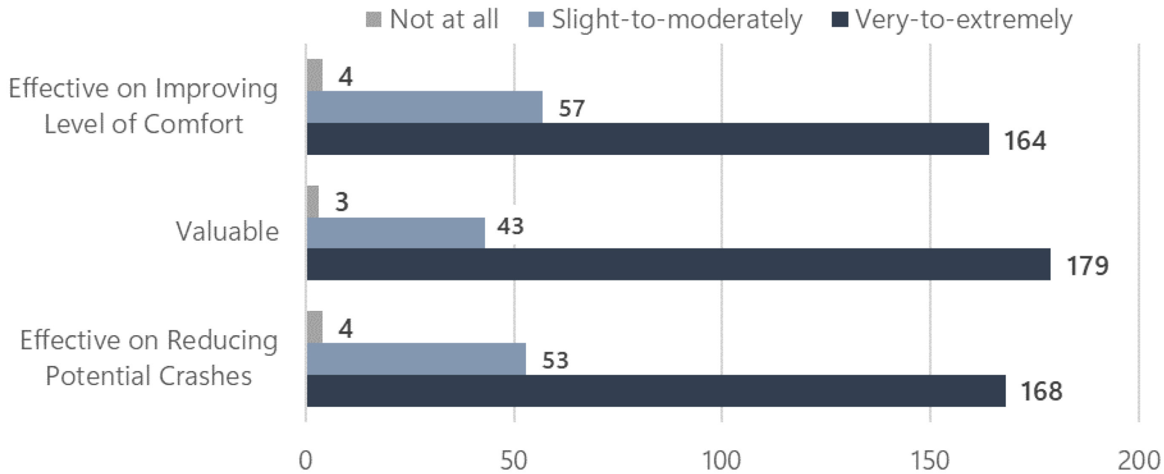


Figure 4.14 - Perceptions of Bike Turnouts, Cyclists Familiar with Being Overtaken (n=225)

As an infographic, Figure 4.15 provides a summary of all respondents' preferences for bike turnouts. Across 307 cyclists and 305 drivers combined, 526 Oregon residents said they would like to see auxiliary bike lanes implemented in Oregon. Further, when asked if they would like to see auxiliary bike lanes implemented in Oregon, an additional 65 respondents selected 'maybe'. Collectively, 591 of 612 respondents exhibit some degree of favor in bike turnouts.

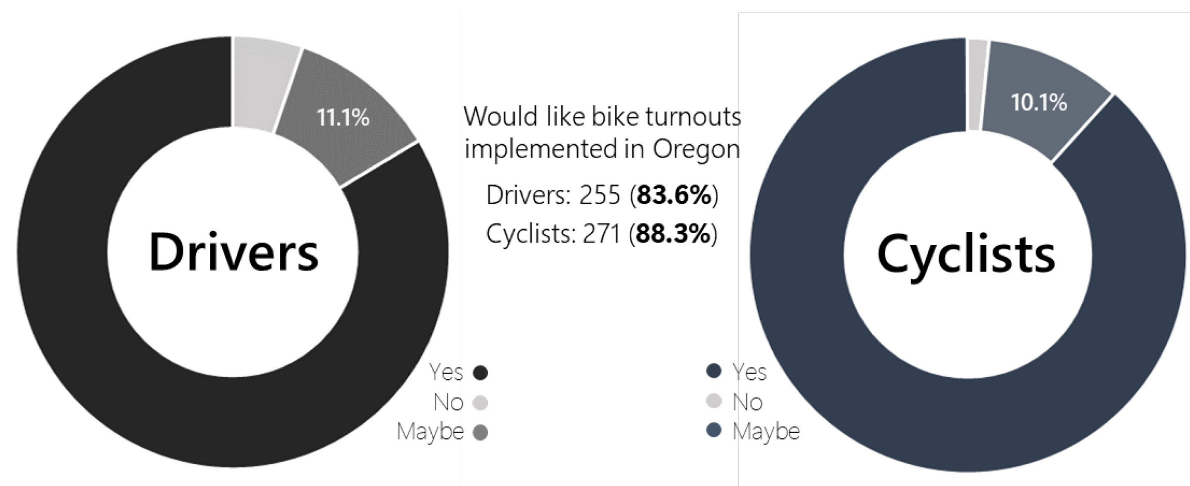


Figure 4.15 - Infographic of Stated Preferences for the Implementation of auxiliary bike lanes in Oregon (Drivers and Cyclists)

Following the first scenario, drivers and cyclists were asked to indicate their familiarity (familiar, unfamiliar, unsure) with driving/biking on roadways "*similar to that of the one in the video"* and further specified as "*tight curves with limited visibility on a 2-lane road with no median, shoulder, or bike lane*". A total of 257 cyclists and 291 drivers indicated they were familiar with biking and driving on such roadways, respectively. When asked if they would like to see auxiliary bike lanes in Oregon, 86.5% said ‘yes’, as shown in Figure 4.16.

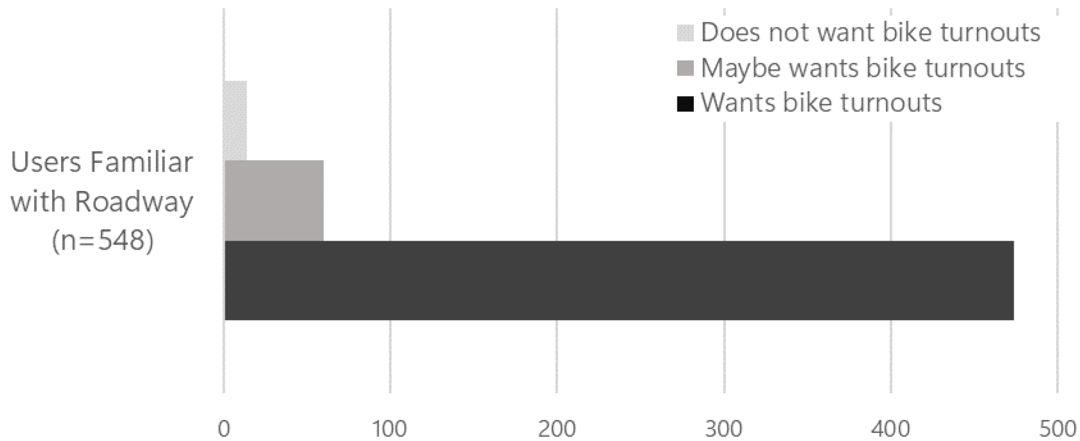


Figure 4.16 - Stated Preference for Auxiliary Bike Lanes in Oregon, Users Familiar with Roadway, n=548 (Drivers and Cyclists)

5.0 DISCUSSION

The following discussion draws attention to the perceptions of users who would benefit most from auxiliary bike lanes, in terms of safety and level of comfort. Secondly, the perceptions and receptivity of those who have experienced an auxiliary bike lane in person are a uniquely revealed preference, and hence are introduced and discussed. Following the discussion of these users' perceptions, the limitations of the auxiliary bike lane design and of the study are each presented and discussed.

5.1 USER PERCEPTIONS

It is worth investigating the user perspectives of the following groups:

- Cyclists familiar with overtaking maneuvers: cyclists who have been overtaken and indicate discomfort when being overtaken,

- Routine rural roadway users: those who are most likely to drive or bike on roadways that would benefit from bike turnouts, and

- Users previously exposed to bike turnouts: drivers and cyclists who have been to Mount Diablo since the implementation of bike turnouts.

5.1.1 Cyclists Familiar with Overtaking Maneuvers

A total of 140 drivers reported to have overtaken a cyclist on a two-lane road (no shoulder or bike lane) with limited visibility. Further, a total of 225 cyclists reported to have been overtaken by a vehicle while biking. These cyclists were then asked, "Overall, how comfortable/uncomfortable are you with a driver overtaking you on a tight curve with limited visibility on a 2-lane road with no median, shoulder, or bike lane?". Altogether, 145 cyclists indicated it made them feel extremely uncomfortable (n=67) or somewhat uncomfortable (n=78). Perceptions of the extent to which auxiliary bike lanes would improve users' level of comfort have significant value among these cyclists and is presented in Figure 5.1. As expected, cyclists who have the greatest discomfort with being overtaken correspondingly perceive auxiliary bike lanes to have the strongest degree of impact on their level of comfort – 49.3% (n=33) and 31.3% (n=21) said auxiliary bike lanes would be *extremely* and *very* effective in improving their level of comfort, respectively. The number cyclists who experience some discomfort with being overtaken also indicated high degrees of effectiveness – these cyclists predominantly indicated the level of effectiveness as *extremely effective* (n=26, 33%) or *very effective* (n=26, 33%) in improving their comfort.

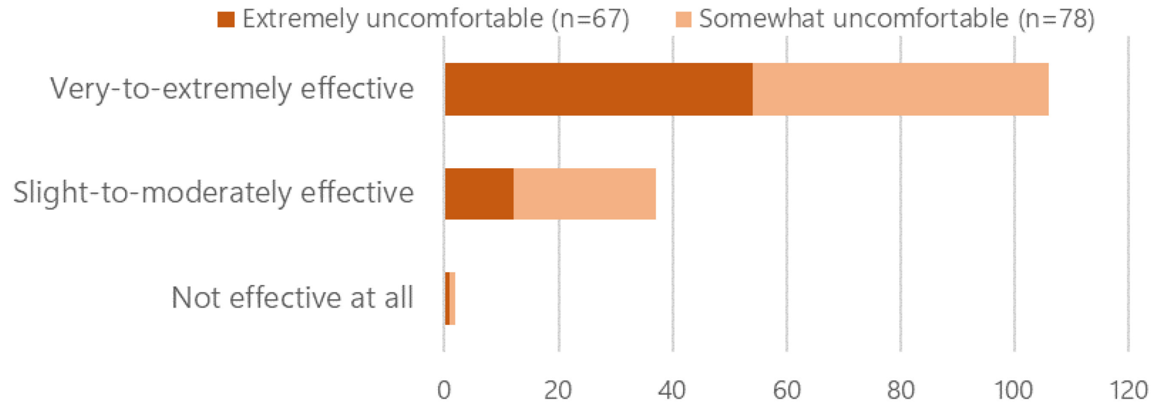


Figure 5.1 - Effectiveness of Bike Turnouts in Improving Level of Comfort of Cyclists that Indicated Overtaking Makes Them Extremely or Somewhat Uncomfortable (n=145)

5.1.2 Routine Rural Roadway Users

A total of 118 drivers reported routinely driving in rural environments and 116 cyclists reported routinely riding in rural environments. Figure 5.2 shows the distribution of these routine rural road users' perceived levels of effectiveness of auxiliary bike lanes in reducing potential crashes. Looking at rural cyclists, approximately 80% perceived auxiliary bike lanes to be very and extremely effective, with almost an equal split. Whereas rural drivers perceived auxiliary bike lanes to be more extremely than very effective. It could be argued that the measured difference between *very* and *extremely* is negligible, such that more than 75.4% of drivers and 80.2% of cyclists perceived auxiliary bike lanes to be highly effective in reducing potential crashes.

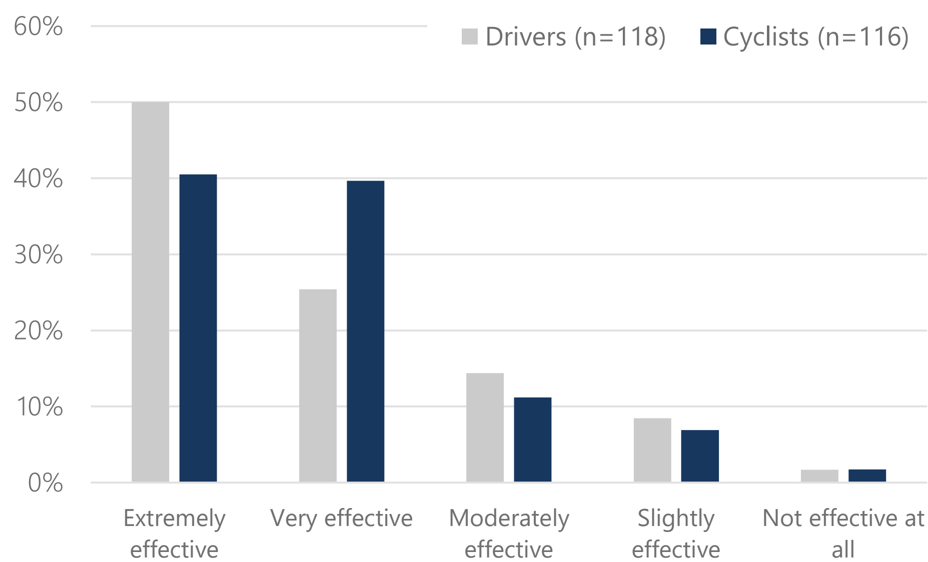


Figure 5.2 - Effectiveness on Perceived Safety, Rural Road Users, n=234 (Drivers and Cyclists)

It is possible drivers respond with stronger beliefs of effectiveness, when compared to cyclists, because of their level of control over the situation. In the open-ended responses to scenario 2, many cyclists concluded that their safety was ultimately a function of the queued driver(s) behavior, and their decision to overtake. While auxiliary bike lanes are intended to eliminate the risk associated with the overtaking maneuver, the ramifications of failed driving response remain significant. Moreover, multiple cyclists touched on the paradoxical nature of auxiliary bike lanes – by adding the safety measure, bike turnouts, motorists may perceive the conditions to be overly safe, and in return, behave less safely. This would result in increased levels of confidence among motorists, which might contribute to increased speeds, decreased attention, and increased perception-reaction times. It is a valid argument to worry that drivers may experience an induced level of confidence resulting in increased operating speeds on curves; however, what is unknown is if the potentially increased speeds would present a more hazardous situation than the overtaking maneuver on the same curve, absent of a bike turnout.

5.1.3 Users Already Familiar with Bike Turnouts

Following the formal education of auxiliary bike lanes, respondents were asked two questions to determine if they were exposed to auxiliary bike lanes. First, respondents were asked "*Prior to this survey, had you heard of "bike turnouts" or had any knowledge of them?*", to which 74 cyclists and 49 drivers responded with 'yes'. Secondly, drivers and cyclists were respectively asked, *"Since the beginning of 2017, have you ever [driven in/biked on the roads in] Mount Diablo State Park located in northern California*?". Since auxiliary bike lanes were first implemented in 2016 and fully integrated by 2017, respondents who indicated 'yes' are likely to have been exposed to auxiliary bike lanes. However, reporting to have driven/biked in MDSP since 2017 does not mean the user encountered an auxiliary bike lane. A second level of validation was applied to this group of 16 cyclists and 18 drivers. Of these, two cyclists and seven drivers indicated that prior to the study, they did *not* have knowledge of or had *not* heard of auxiliary bike lanes, and hence were excluded.

In response to the survey question, "*Would you like to see bike turnouts implemented in Oregon*?", 96% of the twice-validated cyclists and drivers combined (n=25: $n_{Cyclist}$=14; n_{Driver}=11) indicated full-to-partial receptivity towards the implementation auxiliary bike lanes in Oregon. Of the 14 double-validated cyclists, 11 were fully receptive (answer choice='yes') and 3 were partially receptive (answer choice='maybe') to auxiliary bike lanes being implemented in Oregon. Of these drivers, 10 indicated full receptivity to auxiliary bike lanes whereas one driver indicated a favor against the implementation of auxiliary bike lanes. The open-ended responses of those who were not fully receptive were assessed to provide more insight. None of the cyclists' responses were applicable, however, the driver's open-ended response was "Costly" which likely illuminates the reason as to why they were against the implementation of auxiliary bike lanes. Similarly, the open-ended responses of those who were in favor of auxiliary bike lanes were assessed. Four drivers explicitly stated their belief that auxiliary bike lanes are safer for drivers *and* cyclists, each of which are quoted below:

> *"Bike turnouts present a safe option for both motor vehicle drivers and bicyclists. It is in the best interest of all concerned and would be a well implemented, precautionary structure."*

"I think they are awesome! I love the idea of bike turnouts keeping every biker safe!"

"I think this is a good idea because it is safe for the driver and the bike rider. Good idea"

"Safer for bike rider and car driver and better safety for both"

It is worth noting that many other drivers explicitly echoed the same belief that bike turnouts would improve the safety of not just drivers, but cyclists as well.

5.2 CONSIDERATIONS FOR DESIGN

The first consideration was initially theorized by the research team and was subsequently identified by select respondents' open-ended responses, and that is the need for informing drivers upstream of the downstream auxiliary bike lanes. If drivers are informed that a auxiliary bike lane is *X* feet ahead, they may choose to follow the cyclist and wait for the auxiliary bike lane, where otherwise, if there was no knowledge of this auxiliary bike lane, they would execute an overtaking of the cyclist. To the knowledge of the research team, there currently no signs in MDSP that communicate this message. Tangentially, in MDSP, as of April 2023, multiple yellow diamond signs were observed throughout the park, that were in advance of some blind curves that read to drivers, "Do not pass bikes on blind curves". Additionally, a small white, rectangular sign that read to the cyclists, "Bicyclists must use auxiliary bike lanes" was observed at the South Gate entrance to the park.

5.3 LIMITATIONS OF STUDY

Intrinsic to self-administered, online surveys, is the lack of control, which is implicated in the three overarching limitations of this study: (1) data validity due to self-reporting methods, (2) data quality due to inconsistencies in quality of exposure, and (3) data quality due to inadequate or oversaturated exposures. Lastly, given the novelty of auxiliary bike lanes, limitations imposed by stated preference responses, such as hypothetical biases, must be considered.

5.3.1 Self-Reporting Methods

To address issues with self-reporting, multiple screening questions were placed at the beginning of the survey to ensure participants resided in Oregon at the time of the survey and were active users (within 6 months) of the transportation mode corresponding to the survey. Moreover, these screening questions and their answer choices were worded neutrally so ineligible persons could not detect how their answers should be modified to allow for participation.

5.3.2 Quality of Exposure

The survey was designed to mitigate the implications of the uncontrolled nature of the survey, and subsequent variance in exposure quality between participants. One primary goal of the survey design was to ensure sustained, consistent engagement from start to finish to reduce the impact of ongoing environmental distractions. Firstly, at the beginning of the survey, participants were provided with text and a graphic informing them of how their choice to participate and complete the survey to follow would directly contribute to the safety of drivers and cyclists in

Oregon. Secondly, the survey was formatted in blocks, strategically grouping questions on the same or separate pages. As opposed to providing respondents with multiple related questions and videos all at once, they were split up to mitigate participant confusion and to promote completion of the survey. Thirdly, respondents were consistently informed throughout the survey of what tasks were to immediately follow. At the end of each survey page, text stating what the general topic of the next section was provided directly above the arrow button, e.g. "*Next up: Driving Experience*".

5.3.3 Inadequate or Oversaturated Exposure

Similarly, it is assumed that the respondents watched the full video one time through, however, respondents could feasibly begin answering the corresponding questions mid-way through the video. To address this, videos were cropped to be concise and short (<15 seconds). In opposition to inadequate exposure, respondents could have re-winded the video to experience a scenario more than once, resulting in increased exposure. Overexposure would likely manifest in a participant's response quality. On a larger scale, between survey pages, this was prohibited as no 'back' buttons were provided. This design choice also prevented any modifications to previous answers resulting from order bias. Additionally, in their internal quality assurance, Qualtrics' removed any respondents with survey completion durations two standard deviations above or below the mean. The degree of underexposure or overexposure could exist between participants at the scenario-level but could also exist at the participant-level between scenarios.

5.3.4 Hypothetical Biases

Given its novelty and its only known location, Mount Diablo State Park, respondents were assumed to not have prior real-life exposure to bike turnouts. The resulting stated-preference survey design creates an opportunity for hypothetical biases to manifest, specifically in the self-reported level of comfort/discomfort and user perceptions of the effectiveness and value of bike turnouts. While these cannot be explicitly identified and addressed, uniformity and concise language was employed to mitigate the effects of hypothetical biases. Regarding the self-reported level of comfort/discomfort, these were placed after each scenario video with the consistent answer choices, 5-point Likert scale (*Extremely* (un)comfortable, somewhat (un)comfortable, *neither comfortable or uncomfortable*). Secondly, the education of bike turnouts was neutrally worded to merely inform respondents of its definition and purpose, absent of researcher bias favoring or opposing bike turnouts.

5.4 CONCLUSIONS AND RECOMMENDATIONS

Collectively, 97.8% of drivers and cyclists believe that the implementation of auxiliary bike lanes would effectively reduce potential crashes on 2-lane roadways (no shoulder or bike lane) with limited visibility. Furthermore, 170 drivers and 151 cyclists chose to elaborate on this belief in their open-ended responses.

In the open-ended responses related to experiencing the overtaking of the cyclist or being overtaken by the vehicle, 166 drivers and 161 cyclists wrote about their discomfort from their experiences with overtaking maneuvers on Oregon roadways. From a wider lens, 98.2% of drivers and cyclists believe that auxiliary bike lanes would improve their overall level of comfort. In terms of perceived value added from the implementation of auxiliary bike lanes, 90.2% of drivers and 93.2% of cyclists perceived auxiliary bike lanes to be moderately-to-extremely valuable. It is apparent that Oregon drivers and cyclists are highly receptive to the implementation of auxiliary bike lanes as they are perceived to be greatly beneficial for all users and would serve as the only available solution provided.

Responses to the question, "*Would you like to see bike turnouts implemented in Oregon?*" inform strong perceptions of safety, comfort, and value for auxiliary bike lanes. The stated preference in favor of implementing bike turnouts is supported by a significant sample of Oregon drivers *and* cyclists – 84% (n=255) of the drivers and 86% (n=271) of the cyclists selected 'yes' in response to the question. An additional 34 drivers (11.1%) and 31 cyclists (10.1%) showed potential receptivity to the implementation of auxiliary bike lanes in Oregon.

The results provide evidence supporting the conceivability of and receptivity to auxiliary bike lanes by a meaningful sample of drivers and cyclists, representative of the state-wide population. Inherent to online research methods and concept testing are hypothetical biases which may be exhibited by greater and stronger degrees of receptivity and sentiment of auxiliary bike lanes. Biases towards the favoring of bike turnouts may also be present given that there is no current alternative solution proposed. These should not serve to discredit the viability of bike turnouts, rather, they should be accounted for through user-centric design practices.

6.0 REFERENCES

45 Bike Turnouts. (n.d.). Retrieved from https://mountdiablocyclists.org/45-bike-turnouts/

65 Bike vs Vehicle Collision: 2002 to October 2022. (n.d.). Retrieved from https://mountdiablocyclists.org/bike-turnout-project-bike-vs-vehicle-collision-map%ef%bf%bc/

BIKE TURNOUTS MOUNT DIABLO STATE PARK. (2021, March 4). [Video]. Mount Diablo Cyclists. Retrieved from https://www.youtube.com/watch?v=2OaF20iAYhI&t=24s

Bike Turnout Plans (Feb 2022). (n.d.). Retrieved from https://mountdiablocyclists.org/plans/

Bike Turnout Project #2019-05 Mount Diablo State Park. (n.d.). Retrieved from https://mountdiablocyclists.org/breaking-news/bike-turnout-project2091-05-mount-diablo-state-park/

Breuer, H., & Kalin, A. (2023). *Zoom Meeting with Alan Kalin (Pre-Interview Notes)*.

Cyclist Survey. (n.d.). Retrieved from https://mountdiablocyclists.org/cyclist-survey-1-1-18/

Eastbay Times Newspaper. (2017). Retrieved from https://mountdiablocyclists.org/newspaper-articles/

Fatality and Injury Reporting System Tool [Fatality Analysis Reporting System (FARS)]. (2022). National Highway Transportation Safety Administration. Available at https://cdan.dot.gov/query/

Kalin, A. (2023, February 3, 2023) *Interview of Alan Kalin (MDC President) about Bike Turnouts/Interviewer: H. Breuer*.

Kovaceva, J., Nero, G., Bärgman, J., & Dozza, M. (2019). Drivers overtaking cyclists in the real-world: Evidence from a naturalistic driving study. *Safety Science, 119*, 199-206. doi: 10.1016/j.ssci.2018.08.022

Lofholm, D. W. (2022). Mount Diablo State Park Bicycle Passing Lanes. Online: Mount Diablo Cyclists Retrieved from https://mountdiablocyclists.org/plans/MDSP Signing & Striping Improvements Plan (2016). (n.d.). Retrieved from https://mountdiablocyclists.org/mdsp-roadway-signing-striping-improvements-plan/

Motorist Safety Survey. (n.d.). Retrieved from https://mountdiablocyclists.org/motorist-safety-survey/

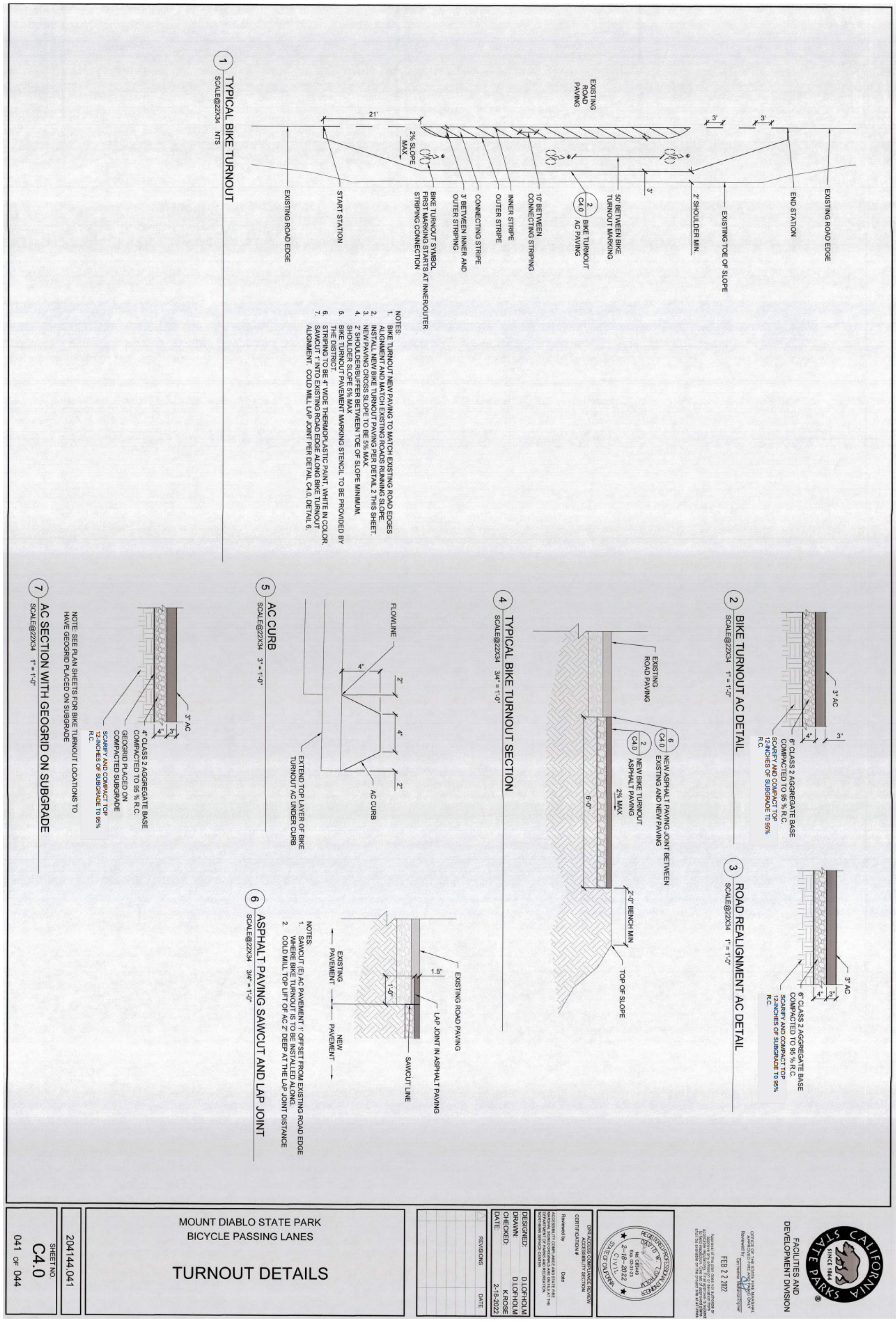
Mount Diablo Challenge. (2022). Retrieved from https://www.strava.com/segments/18491701

Our Story. (n.d.). Retrieved from https://mountdiablocyclists.org/our-story/

Robartes, E., & Chen, T. D. (2017). The effect of crash characteristics on cyclist injuries: An analysis of Virginia automobile-bicycle crash data. *Accident Analysis and Prevention, 104*, 165-173. doi: 10.1016/j.aap.2017.04.020

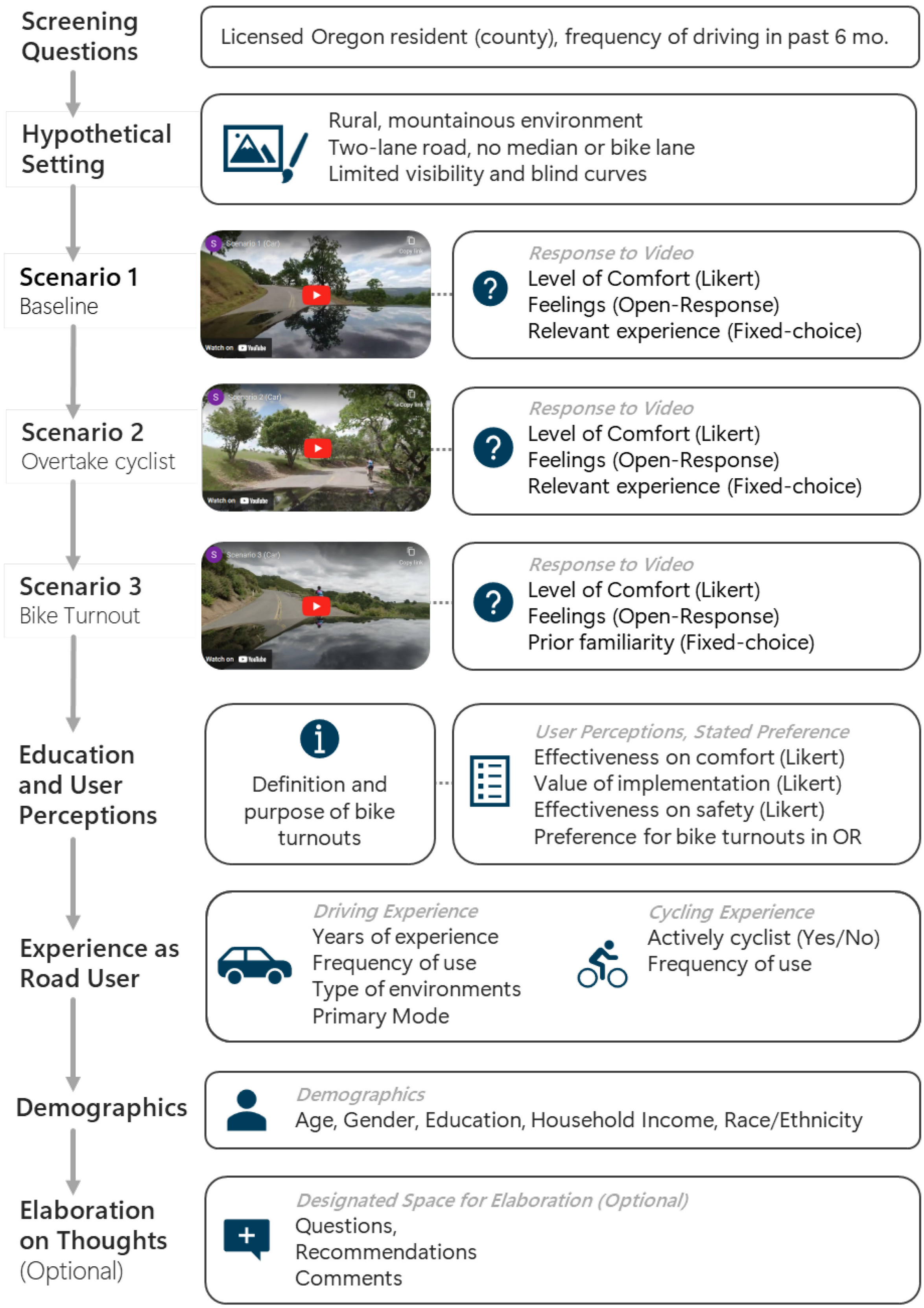
Trujillo, L. (2016). *Mt. Diablo State Park Roadway Signing and Striping Improvements (CSFM # 07-07-11-0038)*. California Department of Parks and Recreation, Acquisitions and Development Division. Retrieved from https://mountdiablocyclists.org/wp-content/uploads/2023/12/Mt-Diablo-Signing-and-Striping-Improvements-11-x-17-1.pdf

APPENDIX A: ENGINEERING DRAWING OF BIKE TURNOUT



Accessible via: PLANS – Mount Diablo Cyclists [(https://mountdiablocyclists.org/plans/)](https://mountdiablocyclists.org/plans/)

APPENDIX B: DRIVER SURVEY FLOWCHART


Screening Questions
Licensed Oregon resident (county), frequency of driving in past 6 mo.
Hypothetical Setting
Rural, mountainous environment
Two-lane road, no median or bike lane
Limited visibility and blind curves
Scenario 1
Baseline
Response to Video
Level of Comfort (Likert)
Feelings (Open-Response)
Relevant experience (Fixed-choice)
Scenario 2
Overtake cyclist
Response to Video
Level of Comfort (Likert)
Feelings (Open-Response)
Relevant experience (Fixed-choice)
Scenario 3
Bike Turnout
Response to Video
Level of Comfort (Likert)
Feelings (Open-Response)
Prior familiarity (Fixed-choice)
Education and User Perceptions
Definition and purpose of bike turnouts
User Perceptions, Stated Preference
Effectiveness on comfort (Likert)
Value of implementation (Likert)
Effectiveness on safety (Likert)
Preference for bike turnouts in OR
Experience as Road User
Driving Experience
Years of experience
Frequency of use
Type of environments
Primary Mode
Cycling Experience
Actively cyclist (Yes/No)
Frequency of use
Demographics
Demographics
Age, Gender, Education, Household Income, Race/Ethnicity
Elaboration on Thoughts (Optional)
Designated Space for Elaboration (Optional)
Questions,
Recommendations
Comments

Text of Driver Survey Flowchart:

1. Screening Questions
2. Hypothetical Setting
    a. Rural, mutinous environment
    b. Two-lane road, no median or bike lane
    c. Limited visibility and blind curves
3. Scenario 1: Baseline
    a. Level of Comfort in a Likert Scale
    b. Feelings in an Open-Response
    c. Relevant Experience in a Fixed-Choice
4. Scenario 2: Overtaking cyclist
    a. Level of Comfort in a Likert Scale
    b. Feelings in an Open-Response
    c. Relevant Experience in a Fixed-Choice
5. Scenario 3: Bike Turnout
    a. Level of Comfort in a Likert Scale
    b. Feelings in an Open-Response
    c. Prior Familiarity in a Fixed-Choice
6. Education and User Perceptions
    a. Definition and purpose of bike turnouts
    b. Stated Preference
        i. Effectiveness on comfort in a Likert Scale
        ii. Value of Implementation in a Likert Scale
        iii. Effectiveness on Safety in a Likert Scale
        iv. Preference for Bike Turnouts in OR
7. Experience as Road User
    a. Driving Experience
        i. Years of Experience
        ii. Frequency of Use
        iii. Type of Environments
        iv. Primary Mode
    b. Cycling Experience
        i. Active Cyclist (yes / no)
        ii. Frequency of Use
8. Demographics
    a. Age, Gender, Education, Household Income, Race/Ethnicity
9. Elaboration on Thoughts (Optional)

APPENDIX C: DRIVER SURVEY

Driver Survey - Final

Start of Block: Block 10

Considerations for Driver and Bicyclist Safety in Oregon
Research conducted by Oregon State University with funding from the Oregon Department of Transportation

Once completed, you will have the opportunity to be entered for a chance to win a **$50 Amazon gift card**!

End of Block: Block 10

Start of Block: Screening Questions

Are you a licensed driver residing in Oregon?

- Yes (1)
- No (2)

Skip To: End of Block If Are you a licensed driver residing in Oregon? = No

Over the past 6 months, how frequently have you driven a car?

- ○ At least every day (1)
- ○ At least every week (2)
- ○ At least every month (4)
- ○ Less than once a month (5)
- ○ Never, I have not driven a car in the past 6 months (6)

Skip To: End of Block If Over the past 6 months, how frequently have you driven a car? = Never, I have not driven a car in the past 6 months

Which county do you reside in?
The purpose of this question is to ensure appropriate representation of the population distribution across Oregon.

- ◯ Baker (1)
- ◯ Benton (2)
- ◯ Clackamas (3)
- ◯ Clatsop (4)
- ◯ Columbia (5)
- ◯ Coos (6)
- ◯ Crook (7)
- ◯ Curry (8)
- ◯ Deschutes (9)
- ◯ Douglas (10)
- ◯ Gilliam (11)
- ◯ Grant (12)
- ◯ Harney (13)
- ◯ Hood River (14)
- ◯ Jackson (15)
- ◯ Jefferson (16)
- ◯ Josephine (17)
- ◯ Klamath (18)
- ◯ Lake (19)
- ◯ Lane (20)

- ○ Lincoln (21)
- ○ Linn (22)
- ○ Malheur (23)
- ○ Marion (24)
- ○ Morrow (25)
- ○ Multnomah (26)
- ○ Polk (27)
- ○ Sherman (28)
- ○ Tillamook (29)
- ○ Umatilla (30)
- ○ Union (31)
- ○ Wallowa (32)
- ○ Wasco (33)
- ○ Washington (34)
- ○ Wheeler (35)
- ○ Yamhill (36)
- ○ None of the above (38)

Skip To: End of Block If Which county do you reside in? The purpose of this question is to ensure appropriate representati... = None of the above

What device are you currently using to complete this survey?

- ◯ Laptop or desktop computer (1)
- ◯ iPad or large tablet device (2)
- ◯ Smartphone or device with similar screen size (3)

End of Block: Screening Questions

Start of Block: Preface

In this survey, you will be presented 3 short video clips.
After each video, we will ask you about your perceived level of comfort and safety as the driver.
Following, we will ask you about your experience as a road user in Oregon.

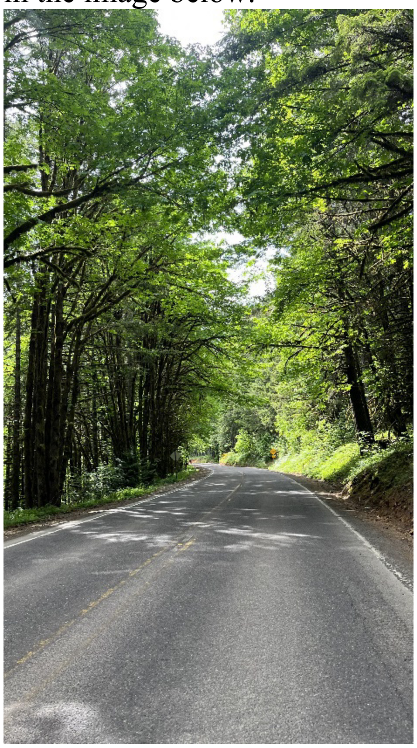
Once completed, you will be able to enter an email address for a chance to win a $50 Amazon gift card!

Page Break

The videos you will be watching are recorded from the driver's point of view to simulate an experience of you driving on the roadway.

It is important for you to *feel* and have the mindset as if you are *actually* driving, so to help you do this, let us first get a better understanding of the type of road and environment you will be 'driving' in...

Imagine it is a bright, clear summer day and you are driving up a mountain range in Oregon, on a two-lane rural highway with **no median**, **no bike lanes**, and **no shoulders**, similar to the road in the image below.



In addition to other drivers, cyclists are known to bike **up and down** this roadway.

Initially, there were some gradual hills and curves connected by stretches of flatter and straighter road. Here, you were able to *easily* and *safely* pass cyclists.

Now you are approaching more mountainous terrain, where the road is winding, with **steeper** gradients and **tighter** curves, similar to the road in the image below.

Page Break

Let us proceed to the video clips and reflective questions. Do your best to try to use your imagination to feel as though you are driving on the roadway.

Please make the video full-screen and rotate your device (if applicable) before watching.

Next up: Video #1

End of Block: Preface

Start of Block: Video 1

Please make the video full-screen and rotate your screen (if applicable) before watching.

Page Break

From the driver's perspective, what was your overall level of comfort/discomfort while watching the video?

- ◯ Extremely uncomfortable (9)
- ◯ Somewhat uncomfortable (10)
- ◯ Neither comfortable or uncomfortable (11)
- ◯ Somewhat comfortable (12)
- ◯ Extremely comfortable (13)

Have you ever driven on a roadway similar to that of the one in the video - tight curves with limited visibility on a 2-lane road with no median, shoulder, or bike lane?

- ◯ Yes (12)
- ◯ No (11)
- ◯ I'm not sure (10)

Display This Question:

If Have you ever driven on a roadway similar to that of the one in the video - tight curves with lim... = Yes

In general, how do you feel as a driver while driving along tight curves with limited visibility on a 2-lane road with no median, shoulder, or bike lane? Please describe below.

____

____

____

____

____

Display This Question:

If Have you ever driven on a roadway similar to that of the one in the video - tight curves with lim... = No

Or Have you ever driven on a roadway similar to that of the one in the video - tight curves with lim... = I'm not sure

In general, how would it make you feel as a driver while driving along tight curves with limited visibility on a 2-lane road with no median, shoulder, or bike lane? Please describe below.

____

Page Break

Let us imagine driving the same segment of roadway again, but now, as you approach the curve, you see a cyclist ahead biking at 5 mph. Since there is no shoulder or bike lane available, the cyclist is positioned in your lane but closest to the outer edge of the roadway.

Based on your own experiences driving in Oregon, which would you be more likely to do?

○ Pass the cyclist: Judge your conditions and surroundings, modify your speed and position as you approach, and then safely pass the cyclist, or (1)

○ Wait behind the cyclist: Slow down and follow behind the cyclist, and wait until the roadway is flat or straight enough to see cars coming in the opposite direction and safely pass the cyclist (2)

Next up: Video #2

End of Block: Video 1

Start of Block: Video 2

Please make the video full-screen and rotate your screen (if applicable) before watching.

Page Break

From the driver's perspective, what was your overall level of comfort/discomfort while watching the video?

- ◯ Extremely uncomfortable (9)
- ◯ Somewhat uncomfortable (10)
- ◯ Neither comfortable or uncomfortable (11)
- ◯ Somewhat comfortable (12)
- ◯ Extremely comfortable (13)

Have you ever passed a cyclist along a tight curve with limited visibility on a 2-lane road with no median, shoulder, or bike lane?

- ◯ Yes (12)
- ◯ No (11)
- ◯ I'm not sure (10)

Display This Question:

If Have you ever passed a cyclist along a tight curve with limited visibility on a 2-lane road with... = Yes

In general, how do you feel as a driver while passing a cyclist along a tight curve with limited visibility on a 2-lane road with no median, shoulder, or bike lane?
Please describe below.

____

____

____

____

____

Display This Question:

If Have you ever passed a cyclist along a tight curve with limited visibility on a 2-lane road with... = No

Or Have you ever passed a cyclist along a tight curve with limited visibility on a 2-lane road with... = I'm not sure

In general, how would it make you feel as a driver to pass a cyclist along a tight curve with limited visibility on a 2-lane road with no median, shoulder, or bike lane?
Please describe below.

____

Next up: Video #3

End of Block: Video 2

Start of Block: Video 3

Please make the video full-screen and rotate your screen (if applicable) before watching.

Page Break

From the driver's perspective, what was your overall level of comfort/discomfort while watching the video?

- ◯ Extremely uncomfortable (9)
- ◯ Somewhat uncomfortable (10)
- ◯ Neither comfortable or uncomfortable (11)
- ◯ Somewhat comfortable (12)
- ◯ Extremely comfortable (13)

End of Block: Video 3

Start of Block: Education

The roadway treatment presented in the last video is called a "bike turnout" and is shown through drone imagery below.

The purpose of a bike turnout is to improve the safety of drivers and cyclists on hilly and/or winding road segments during which a driver wants to pass (overtake) a cyclist ahead but is conflicted as they cannot see far enough down the road to be sure there is no opposing driver or cyclist coming downhill.

Essentially, bike turnouts serve as intermediate bike lanes during which a driver can safely pass cyclists without entering the opposing travel lane, with the risk of colliding with a driver or cyclist traveling in the opposite direction.

End of Block: Education

Start of Block: Post-ed Questions

Bike Turnouts

Would you like to see bike turnouts implemented on Oregon roadways?

○ Yes (1)

○ Maybe (2)

○ No (3)

From your perspective as a driver, please describe your thoughts and feelings towards bike turnouts.

____

____

____

____

____

Page Break

How *effective* do you think bike turnouts would be in improving your level of comfort when passing a cyclist along a tight curve with limited visibility on a 2-lane road with no median, shoulder, or bike lane?

- Not effective at all (1)
- Slightly effective (2)
- Moderately effective (3)
- Very effective (4)
- Extremely effective (5)

In general, how *valuable* do you think it would it be to implement bike turnouts on tight curves with limited visibility?

- Not valuable (1)
- Slightly valuable (2)
- Moderately valuable (3)
- Very valuable (4)
- Extremely valuable (5)

How *effective* do you think bike turnouts would be in reducing potential crashes on tight curves with limited visibility?

- Not effective at all (1)
- Slightly effective (2)
- Moderately effective (3)
- Very effective (4)
- Extremely effective (5)

Page Break

JS *

How many years have you driven in Oregon?
If you have recently moved here and have not driven in Oregon for a full year, please round up to 1 year.

____

What is your **primary mode** of transportation for commuting, running errands, getting to/from events and activities?

- Car (1)
- Bike (2)
- Public transit (bus, rail, etc.) (3)
- Walking (4)
- Other (scooter, Uber/Lyft, etc.) (5)

Next up: Cycling Experience

End of Block: Driving Experience

Start of Block: Cycling Experience

Cycling Experience

What type of cyclist would you classify yourself as?

○ Strong and Fearless (i.e. individuals who would ride a bicycle regardless of roadway conditions) (1)

○ Enthused and Confident (i.e. individuals who are comfortable sharing roadway with motorized vehicles but would prefer to ride in own facilities designated for cyclists) (2)

○ Interested but Concerned (i.e. individuals who hear about promotion of cycling and are interested in riding, but may be afraid because of conditions of roadway) (3)

○ No Way, No How (i.e. individuals who will not ride regardless of the roadway conditions) (4)

Do you actively use a bicycle on Oregon roadways for travel/commuting, recreational, and/or exercise purposes?

○ Yes (1)

○ No (2)

Display This Question:

If Do you actively use a bicycle on Oregon roadways for travel/commuting, recreational, and/or exerc... = Yes

For what purpose(s) do you bike on the roadway? (check all that apply)

- ▢ Exercise/Sport (1)
- ▢ Recreation (2)
- ▢ Travel/Commuting/Errands (3)

Display This Question:

If Do you actively use a bicycle on Oregon roadways for travel/commuting, recreational, and/or exerc... = Yes

Over the past 6 months, how frequently have you ridden a bike on Oregon roadways?

- ○ At least every day (1)
- ○ At least every week (2)
- ○ At least every month (3)
- ○ Less than once a month (4)
- ○ Never, I have not ridden a bike on Oregon roadways in the past 6 months (5)

Next up: Demographics

End of Block: Cycling Experience

Start of Block: Demographics

Demographics

---

*

How old are you?

____

What best describes your gender?

- ○ Female (1)
- ○ Male (2)
- ○ Non-binary (3)
- ○ Prefer not to answer (4)
- ○ Prefer to self-describe (5) ____

Choose one or more races that you consider yourself to be

- ☐ White or Caucasian (1)
- ☐ Black or African American (2)
- ☐ American Indian/Native American or Alaska Native (3)
- ☐ Asian (4)
- ☐ Native Hawaiian or Other Pacific Islander (5)
- ☐ Other (6)
- ☐ Prefer not to say (7)

What is the highest level of education you have completed?

- ◯ Some high school or less (1)
- ◯ High school diploma or GED (2)
- ◯ Some college, but no degree (3)
- ◯ Associates or technical degree (4)
- ◯ Bachelor's degree (5)
- ◯ Graduate or professional degree (MA, MS, MBA, PhD, JD, MD, DDS etc.) (6)
- ◯ Prefer not to say (7)

What was your total household income before taxes during the past 12 months?

- ◯ Less than $25,000 (1)
- ◯ $25,000-$49,999 (2)
- ◯ $50,000-$74,999 (3)
- ◯ $75,000-$99,999 (4)
- ◯ $100,000-$149,999 (5)
- ◯ $150,000 or more (6)
- ◯ Prefer not to say (7)

End of Block: Demographics

Start of Block: Final Thoughts

If you have any questions, recommendations, or comments regarding bike turnouts, please share them here.

If you do not have any, you may skip the questions and press the next button to submit your survey and enter for a chance to win a $50 Amazon gift card!

Do you have any ***questions*** about bike turnouts?

____

____

____

____

____

Do you have any ***recommendations*** regarding bike turnouts?

____

____

____

____

____

Do you have any ***comments*** about bike turnouts?

____

____

____

____

____

Proceed to complete and submit your survey

End of Block: Final Thoughts

Start of Block: Amazon Gift Card

Please enter your email address if you would like a chance to win a $50 Amazon gift card.

____

Privacy Notice: All responses will remain anonymous. Before processing the survey responses, all emails will be separated and exported to a temporary Excel file to randomly select the gift card recipients. Once the winners are selected, **this file and all emails will be permanently deleted.**

End of Block: Amazon Gift Card

Prior to this survey, had you heard of "bike turnouts" or had any knowledge of them?

- ○ Yes (1)
- ○ No (2)
- ○ I am unsure (3)

Since the beginning of 2017, have you ever driven in Mount Diablo State Park located in northern California?

- ○ Yes (1)
- ○ No (2)
- ○ I am unsure (3)

Next up: Driving Experience

End of Block: Post-ed Questions

Start of Block: Driving Experience

Driving Experience

Which environments do you routinely drive in?

- ☐ City/Urban (1)
- ☐ Suburban (2)
- ☐ Rural (3)

APPENDIX D: CYCLIST SURVEY

Start of Block: intro

Considerations for Driver and Bicyclist Safety in Oregon
Research conducted by Oregon State University with funding from the Oregon Department of Transportation

Once completed, you will have the opportunity to be entered for a chance to win a **$50 Amazon gift card**!

End of Block: intro

Start of Block: Screening Questions

Do you actively use a bicycle on Oregon roadways for travel/commuting, recreational, and/or exercise purposes?

○ Yes (1)

○ No (2)

Skip To: End of Block If Do you actively use a bicycle on Oregon roadways for travel/commuting, recreational, and/or exerc... = No

Over the past 6 months, how frequently have you ridden a bike on Oregon roadways?

- ○ At least every day (1)
- ○ At least every week (2)
- ○ At least every month (4)
- ○ Less than once a month (5)
- ○ Never, I have not ridden a bike on Oregon roadways in the past 6 months (6)

Skip To: End of Block If Over the past 6 months, how frequently have you ridden a bike on Oregon roadways? = Never, I have not ridden a bike on Oregon roadways in the past 6 months

Which county do you reside in?
The purpose of this question is to ensure appropriate representation of the population distribution across Oregon.

- ○ Baker (1)
- ○ Benton (2)
- ○ Clackamas (3)
- ○ Clatsop (4)
- ○ Columbia (5)
- ○ Coos (6)
- ○ Crook (7)
- ○ Curry (8)
- ○ Deschutes (9)
- ○ Douglas (10)
- ○ Gilliam (11)
- ○ Grant (12)
- ○ Harney (13)
- ○ Hood River (14)
- ○ Jackson (15)
- ○ Jefferson (16)
- ○ Josephine (17)
- ○ Klamath (18)
- ○ Lake (19)
- ○ Lane (20)

- Lincoln (21)
- Linn (22)
- Malheur (23)
- Marion (24)
- Morrow (25)
- Multnomah (26)
- Polk (27)
- Sherman (28)
- Tillamook (29)
- Umatilla (30)
- Union (31)
- Wallowa (32)
- Wasco (33)
- Washington (34)
- Wheeler (35)
- Yamhill (36)
- None of the above (39)

Skip To: End of Block If Which county do you reside in? The purpose of this question is to ensure appropriate representati... = None of the above

What device are you currently using to complete this survey?

- ○ Laptop or desktop computer (1)
- ○ iPad or large tablet device (2)
- ○ Smartphone or device with similar screen size (3)

End of Block: Screening Questions

Start of Block: Preface

In this survey, you will be presented 3 short video clips.
After each video, we will ask you about your perceived level of comfort and safety as the cyclist.
Following, we will ask questions regarding your experience as a road user in Oregon.

Once completed, you will be able to enter an email address for a chance to win a $50 Amazon gift card!

Page Break

The videos you will be watching are recorded from the cyclist's point of view to simulate and experience of you biking on the roadway.

It is important for you to *feel* and have the mindset as if you are *actually* biking this road, so to help you do this, let us first get a better understanding of the type of road and environment you will be 'biking' in...

Imagine it is a bright, clear summer day and you are biking up a mountain range in Oregon, on a two-lane rural highway with **no median**, **no bike lanes**, and **no shoulders**, similar to the road in the image below.

There are drivers on the roadway traveling in both directions, however it is not a steady stream of vehicles. In addition to yourself, other cyclists are known to bike up and down this roadway. Initially, there were some gradual hills and curves connected by stretches of flatter and straighter road. Here, if needed, drivers were able to *easily* and *safely* pass you.

Now you are approaching more mountainous terrain, where the road is winding, with **steeper** gradients and **tighter** curves, similar to the road in the image below.

Page Break

Let us proceed to the video clips and reflective questions. Do your best to try to use your imagination to feel as though you are biking on the roadway.

Please make the video full-screen and rotate your device (if applicable) before watching.

Next up: Video #1

End of Block: Preface

Start of Block: Video 1

Please make the video full-screen and rotate your screen (if applicable) before watching.

Page Break

From the cyclist's perspective, what was your overall level of comfort/discomfort while watching the video?

- ◯ Extremely uncomfortable (9)
- ◯ Somewhat uncomfortable (10)
- ◯ Neither comfortable or uncomfortable (11)
- ◯ Somewhat comfortable (12)
- ◯ Extremely comfortable (13)

Have you ever biked on a roadway similar to that of the one in the video - tight curves with limited visibility on a 2-lane road with no median, shoulder, or bike lane?

- ◯ Yes (12)
- ◯ No (11)
- ◯ I'm not sure (10)

Display This Question:

If Have you ever Scenario 1 = Yes

In general, how do you feel as a cyclist while biking along tight curves (no vehicles present) with limited visibility on a 2-lane road with no median, shoulder, or bike lane?
Please describe below.

____

____

____

____

____

Display This Question:

If Have you ever Scenario 1 = No

Or Have you ever Scenario 1 = I'm not sure

In general, how would it make you feel as a cyclist to bike along tight curves (no vehicles present) with limited visibility on a 2-lane road with no median, shoulder, or bike lane? Please describe below.

____

____

____

____

____

Let us imagine biking the same segment of roadway again, but now, as you approach the curve, you hear a vehicle approaching from behind. Given there is no shoulder or bike lane available, you must decide how to position yourself.

Based on your own experiences biking in Oregon, which would you be more likely to do?

- ◯ Move closest to the outer edge of the road to allow the vehicle to pass (1)
- ◯ Move towards the center of the lane to prevent the vehicle from passing (2)
- ◯ Stop, and move to the edge of the road and wait for the vehicle to pass (3)

Next up: Video #2

End of Block: Video 1

Start of Block: Video 2

Please make the video full-screen and rotate your screen (if applicable) before watching.

Page Break

From the cyclist's perspective, what was your overall level of comfort/discomfort while watching the video?

- ○ Extremely uncomfortable (9)
- ○ Somewhat uncomfortable (10)
- ○ Neither comfortable or uncomfortable (11)
- ○ Somewhat comfortable (12)
- ○ Extremely comfortable (13)

In general, how do you feel as a cyclist while biking along tight curves (when vehicles are present) with limited visibility on a 2-lane road with no median, shoulder, or bike lane? Please describe below.

____

____

____

____

____

Page Break

Have you ever been overtaken by a driver on a roadway similar to that of the one in the video - tight curves with limited visibility on a 2-lane road with no median, shoulder, or bike lane?

- Yes (1)
- No (2)
- I'm not sure (3)

Overall, how comfortable/uncomfortable are you with a driver overtaking you on a tight curve with limited visibility on a 2-lane road with no median, shoulder, or bike lane?

- Extremely uncomfortable (9)
- Somewhat uncomfortable (10)
- Neither comfortable or uncomfortable (11)
- Somewhat comfortable (12)
- Extremely comfortable (13)

Next up: Video #3

End of Block: Video 2

Start of Block: Video 3

Please make the video full-screen and rotate your screen (if applicable) before watching.

Page Break

From the cyclist's perspective, what was your overall level of comfort/discomfort while watching the video?

- ◯ Extremely uncomfortable (9)
- ◯ Somewhat uncomfortable (10)
- ◯ Neither comfortable or uncomfortable (11)
- ◯ Somewhat comfortable (12)
- ◯ Extremely comfortable (13)

End of Block: Video 3

Start of Block: Education

The roadway treatment presented in the last video is called a "bike turnout" and is shown through drone imagery below.

The purpose of a bike turnout is to improve the safety of drivers and cyclists on hilly and/or winding road segments during which a driver wants to pass (overtake) a cyclist ahead but is conflicted as they cannot see far enough down the road to be sure there is no opposing driver or cyclist coming downhill.

Essentially, bike turnouts serve as intermediate bike lanes during which a driver can safely pass cyclists without entering the opposing travel lane, with the risk of colliding with a driver or cyclist traveling in the opposite direction.

End of Block: Education

Start of Block: Post-ed Questions

Bike Turnouts

Would you like to see bike turnouts implemented in Oregon?

- Yes (1)
- Maybe (2)
- No (3)

From your perspective as a cyclist, please describe your thoughts and feelings towards bike turnouts.

____

____

____

____

____

Page Break

How *effective* do you think bike turnouts would be in improving your level of comfort when biking along tight curves (vehicles are present) with limited visibility on a 2-lane road with no median, shoulder, or bike lane?

- ◯ Not effective at all (1)
- ◯ Slightly effective (2)
- ◯ Moderately effective (3)
- ◯ Very effective (4)
- ◯ Extremely effective (5)

In general, how *valuable do you think it* would it be to implement bike turnouts on tight curves with limited sight distance?

- ◯ Not valuable (1)
- ◯ Slightly valuable (2)
- ◯ Moderately valuable (3)
- ◯ Very valuable (4)
- ◯ Extremely valuable (5)

How *effective* do you think bike turnouts would be in reducing potential crashes on tight curves with limited sight distance?

- ◯ Not effective at all (1)
- ◯ Slightly effective (2)
- ◯ Moderately effective (3)
- ◯ Very effective (4)
- ◯ Extremely effective (5)

Page Break

Prior to this survey, had you heard of "bike turnouts" or had any knowledge of them?

- ◯ Yes (1)
- ◯ No (2)
- ◯ I am unsure (3)

Since the beginning of 2017, have you ever biked on the roads in Mount Diablo State Park located in northern California?

- ◯ Yes (1)
- ◯ No (2)
- ◯ I am unsure (3)

Next up: Cycling Experience

End of Block: Post-ed Questions

Start of Block: Cycling Experience

Cycling Experience

What type of cyclist would you classify yourself as?

- ○ Strong and Fearless (i.e. individuals who would ride a bicycle regardless of roadway conditions) (1)
- ○ Enthused and Confident (i.e. individuals who are comfortable sharing roadway with motorized vehicles but would prefer to ride in own facilities designated for cyclists) (2)
- ○ Interested but Concerned (i.e. individuals who hear about promotion of cycling and are interested in riding, but may be afraid because of conditions of roadway) (3)
- ○ No Way, No How (i.e. individuals who will not ride regardless of the roadway conditions) (4)

For what purpose(s) do you bike on the roadway? (check all that apply)

- ☐ Exercise/Sport (1)
- ☐ Recreation (2)
- ☐ Travel/Commuting/Errands (3)

Which environments do you routinely bike in?

- ☐ City/Urban (1)
- ☐ Suburban (2)
- ☐ Rural (3)

Overall, how many years of experience have you had biking?

- <1 year (1)
- 1-5 years (2)
- 5-10 years (3)
- More than 10 years (5)

What is your **primary** mode of transportation for commuting, running errands, getting to/from events and activities?

- Car (2)
- Bike (3)
- Public transit (bus, rail, etc.) (4)
- Walking (5)
- Other (scooter, Uber/Lyft, etc.) (6)

Next up: Driving Experience

End of Block: Cycling Experience

Start of Block: Driving Experience

Driving Experience

Do you actively drive on Oregon roadways?

- Yes (1)
- No (2)

Display This Question:

If Do you actively drive on Oregon roadways? = Yes

JS *

How many years have you driven in Oregon?
If you have recently moved here and have not driven in Oregon for a full year, please round up to 1 year.

____

Display This Question:

If Do you actively drive on Oregon roadways? = Yes

Over the past 6 months, how frequently have you driven a car?

- At least every day (1)
- At least every week (2)
- At least every month (3)
- Less than once a month (4)
- Never, I have not driven a car in the past 6 months (5)

Display This Question:

If Do you actively drive on Oregon roadways? = Yes

Which environments do you routinely drive in?

☐ City/Urban (1)

☐ Suburban (2)

☐ Rural (3)

Next up: Demographics

End of Block: Driving Experience

Start of Block: Demographics

Demographics

---

*

How old are you?

____

What best describes your gender?

○ Female (1)

○ Male (2)

○ Non-binary (3)

○ Prefer not to answer (4)

○ Prefer to self-describe (5) ____

Choose one or more races that you consider yourself to be

- ☐ White or Caucasian (1)
- ☐ Black or African American (2)
- ☐ American Indian/Native American or Alaska Native (3)
- ☐ Asian (4)
- ☐ Native Hawaiian or Other Pacific Islander (5)
- ☐ Other (6)
- ☐ Prefer not to say (7)

What is the highest level of education you have completed?

- ○ Some high school or less (1)
- ○ High school diploma or GED (2)
- ○ Some college, but no degree (3)
- ○ Associates or technical degree (4)
- ○ Bachelor's degree (5)
- ○ Graduate or professional degree (MA, MS, MBA, PhD, JD, MD, DDS etc.) (6)
- ○ Prefer not to say (7)

What was your total household income before taxes during the past 12 months?

- ◯ Less than $25,000 (1)
- ◯ $25,000-$49,999 (2)
- ◯ $50,000-$74,999 (3)
- ◯ $75,000-$99,999 (4)
- ◯ $100,000-$149,999 (5)
- ◯ $150,000 or more (6)
- ◯ Prefer not to say (7)

End of Block: Demographics

Start of Block: Final Thoughts

If you have any questions, recommendations, or comments regarding bike turnouts, please share them here.

If you do not have any, you may skip the questions and press the next button to submit your survey and enter for a chance to win a $50 Amazon gift card!

Do you have any ***questions*** about bike turnouts?

____

____

____

____

____

Do you have any ***recommendations*** regarding bike turnouts?

____

____

____

____

____

Do you have any ***comments*** about bike turnouts?

____

____

____

____

____

Proceed to complete and submit your survey

End of Block: Final Thoughts

Start of Block: Amazon Gift

Please enter your email address if you would like a chance to win a $50 Amazon gift card.

____

Privacy Notice: All responses will remain anonymous. Before processing the survey responses, all emails will be separated and exported to a temporary Excel file to randomly select the gift card recipients. Once the winners are selected, **this file and all emails will be permanently deleted.**

End of Block: Amazon Gift