Cycling Innovations
THE CHALLENGES OF SUPPORTING PEOPLE WHO CYCLE IN A TRANSITION TO SUSTAINABLE MOBILITY

Matthew Bruno
Cycling Innovations: The Challenges of Supporting People Who Cycle in a Transition to Sustainable Mobility

PROEFSCHRIFT

ter verkrijging van de graad van doctor aan de Technische Universiteit Eindhoven, op gezag van de rector magnificus prof.dr.ir. F.P.T. Baaijens, voor een commissie aangewezen door het College voor Promoties, in het openbaar te verdedigen op vrijdag 25 november 2022 om 16:00 uur

door

Matthew Bruno

geboren te Duluth, Minnesota, Verenigde Staten
Dit proefschrift is goedgekeurd door de promotoren en de samenstelling van de promotiecommissie is als volgt:

<table>
<thead>
<tr>
<th>Voorzitter:</th>
<th>prof.dr.ir. Y.A.W. de Kort</th>
</tr>
</thead>
<tbody>
<tr>
<td>Promotor:</td>
<td>prof.dr. R. Oldenziel</td>
</tr>
<tr>
<td>Copromotoren:</td>
<td>dr. F. Behrendt</td>
</tr>
<tr>
<td></td>
<td>dr. A.A. Nikolaeva</td>
</tr>
<tr>
<td></td>
<td>(Universiteit van Amsterdam)</td>
</tr>
<tr>
<td>Promotiecommissieleden:</td>
<td>prof.dr. M. Freudendal-Pedersen (Aalborg University)</td>
</tr>
<tr>
<td></td>
<td>prof.dr.ir. P.J.V. van Wesemael</td>
</tr>
<tr>
<td></td>
<td>prof. dr. J.F. Jeekel</td>
</tr>
<tr>
<td></td>
<td>dr. F. Sharmeen (KTH Royal Institute of Technology)</td>
</tr>
<tr>
<td>Adviseur:</td>
<td>dr. L. Harms (Dutch Cycling Embassy)</td>
</tr>
<tr>
<td></td>
<td>dr. A.A. Albert De La Bruheze (Universiteit Twente)</td>
</tr>
</tbody>
</table>

Het onderzoek of ontwerp dat in dit proefschrift wordt beschreven is uitgevoerd in overeenstemming met de TU/e Gedragscode Wetenschapsbeoefening
# Table of Contents

**ABSTRACT** .................................................................................................................. 5  
**ACKNOWLEDGEMENTS** ............................................................................................. 6  
**CHAPTER 1: INTRODUCTION** ....................................................................................... 8  
1. **PROBLEM STATEMENT, RESEARCH QUESTIONS AND KEY TERMS** ..................... 10  
2. **THEORETICAL BACKGROUND** ............................................................................... 17  
3. **METHODS** ........................................................................................................... 28  
4. **STRENGTHS AND LIMITATIONS OF A QUALITATIVE APPROACH** ....................... 35  
5. **KEY CHAPTER INFORMATION** ........................................................................... 37  
**CHAPTER 2: CYCLING AND TRANSITIONS THEORIES: A CONCEPTUAL FRAMEWORK TO ASSESS THE RELATIONSHIP BETWEEN CYCLING INNOVATIONS AND SUSTAINABILITY GOALS** .................................................. 39  
1. **INTRODUCTION** ................................................................................................... 39  
2. **THEORETICAL FRAMEWORKS TO ASSESS THE RELATIONSHIP BETWEEN CYCLING INNOVATIONS AND SUSTAINABILITY TRANSITIONS** ......................................................................................... 40  
3. **METHODS AND MATERIAL** .............................................................................. 49  
4. **RESULTS** ............................................................................................................ 52  
5. **DISCUSSION AND CONCLUSION** ..................................................................... 61  
1. **INTRODUCTION** ................................................................................................... 63  
2. **METHODS** ........................................................................................................... 64  
3. **THEORETICAL BACKGROUND** ............................................................................ 65  
4. **HISTORICAL CONTEXT** ...................................................................................... 66  
5. **RESULTS** ............................................................................................................ 70  
6. **DISCUSSION** ....................................................................................................... 79  
7. **CONCLUSION** .................................................................................................... 80  
**CHAPTER 4: THE CHALLENGE OF THE BICYCLE STREET: APPLYING COLLABORATIVE GOVERNANCE PROCESSES WHILE PROTECTING USER CENTERED INNOVATION** .................................................. 85  
1. **INTRODUCTION** ................................................................................................... 85  
2. **METHODS** ........................................................................................................... 87  
3. **THEORY** ............................................................................................................. 88  
4. **THE ORIGINS AND PURPOSE OF THE BICYCLE STREET IN GERMANY, BELGIUM, AND THE NETHERLANDS** ................................................................. 91  
5. **DEVELOPMENT AND IMPLEMENTATION OF A BICYCLE STREET ON THE KRUISSTRAAT IN EINDHOVEN** ............................................................. 96  
6. **DISCUSSION** ....................................................................................................... 102  
7. **CONCLUSION** .................................................................................................... 104
CHAPTER 5: TOWARDS A MAINTENANCE-BASED APPROACH TO MODE SHIFT: COMPARING TWO CASES OF DUTCH CYCLING POLICY USING SOCIAL PRACTICE THEORY .......................... 109

1  INTRODUCTION ............................................................................................................................ 109
2  RESEARCH DESIGN AND METHODOLOGY ............................................................................. 111
3  SOCIAL PRACTICE THEORY AND TRANSITIONS TO SUSTAINABLE TRANSPORTATION ............ 112
4  TWO DUTCH NATIONAL BICYCLE POLICIES: AN OVERVIEW .............................................. 115
5  COMPARATIVE ANALYSIS OF THE BICYCLE MASTER PLAN AND WITH THE BICYCLE LESS CONGESTION 119
6  DISCUSSION ................................................................................................................................. 123
7  CONCLUSION ............................................................................................................................... 127

CHAPTER 6: CONCLUSION .................................................................................................................. 129

1  KEY CHAPTER RESULTS ............................................................................................................... 131
2  OVERALL RESULTS AND CONTRIBUTION .................................................................................. 134
3  LIMITATIONS AND FURTHER RESEARCH ............................................................................... 136
4  POLICY RECOMMENDATIONS .................................................................................................... 138

REFERENCES .............................................................................................................................................. 140
Cycling Innovations: The Challenges of Supporting People Who Cycle in a Transition to Sustainable Mobility

Abstract

This dissertation combines different theories of reconfiguration processes with insights from critical mobility scholarship in order to better understand the role of cycling innovations in a mature cycling country and the challenges of implementing innovations that support people who cycle as part of a transition to sustainable mobility systems. It presents a framework for evaluating whether or not cycling innovations advance sustainability goals. Additionally, it uses historical and present-day examples from the Netherlands to demonstrate how different types of innovations are developed and implemented. It argues that using the knowledge of people who cycle and directing cycling innovations towards supporting people who already cycle can help advance a transition to sustainable mobility systems where cycling plays a key role. It demonstrates that people who cycle have been influential in the development and implementation of cycling innovations that restrict car parking, access, and speeds, allowing for the creation of spaces in which cycling is a safe and effective form of transportation. It also notes that people who cycle have often been seen by policymakers as slowing down cars, leading to innovations that manage people who cycle to increase the efficiency of the system of automobility. Some cycling innovations therefore, focus on improving the efficiency of automobility while others support people who cycle and advance a transition to sustainable mobility systems. Each of these findings builds on existing scholarship that has applied theories of reconfiguration processes to transportation systems and adds insights from critical mobility scholarship in order to make a unique contribution to the understanding of the role of innovations that support people who cycle in the transition to sustainable mobility systems.
Acknowledgements

While I may be standing alone at the podium during my defense, a PhD is always a collective effort that is only made possible through the assistance of a great number of people. In the broadest sense, I would like to acknowledge the Dutch Ministry of Infrastructure & Environment, the Dutch Ministry of the Interior, the Dutch Research Council and knowledge and network organization Platform31 that came together to develop a research program within the existing Connecting Sustainable Cities initiative. This research program, Smart Urban Regions of the Future (SURF), was created to determine the best ways to advance economic, social, and environmental goals within Dutch urban regions (Van Oort et al., 2014). Marco te Brömmelstroet and Rob Raven were instrumental in creating the Smart Cycling Futures research program within the SURF project and this research would not exist without the efforts of a number of people in all of these organizations that I will likely never have the chance to thank personally.

I am quite grateful for the advice, assistance, and friendship of my many co-workers in the Technology, Innovation & Society group in the department of Industrial Engineering and Innovations Sciences at Eindhoven University of Technology, as well as our specific project partners in the region. This research would not have been possible without the access to resources and knowledge provided by Bas Braakman in his role of bicycle coordinator for the city of Eindhoven, Nathan Hooghof in his role of cycling project leader with the Province of North Brabant, and Hugo van der Steenhoven, who not only helped organize our meetings, but gave us access to us vast wealth of knowledge as a former politician and head of the Dutch Cyclists’ Union.

At Eindhoven University of Technology, I’m particularly appreciative of the time that fellow mobility researchers Henk-Jan Dekker, Patrick Bek, Sun Qi, Brett Petzer, George Liu, and Jan Ploeger dedicated to reviewing and improving my work. As part of a project working across universities and across disciplines, I was also fortunate to have support from the other researchers in my Smart Cycling Futures group. This included Samuel Nello-Deakin at the University of Amsterdam, Hugo Kampen at Windesheim College in Zwolle and Arnoud van Waes, my officemate every Tuesday for four years at the Copernicus Institute of Sustainable Development in Utrecht.

Last but certainly not least, I would like to thank my supervision team. I will always fondly remember the first years of this project in the old IPO building, working through ideas with Frank Schipper on a giant blackboard in the room with a small library and large table tennis set. In the years when the COVID-19 crisis created additional challenges for completing my articles, Frauke Behrendt was consistently helpful in working through revisions at a distance. In all her different roles – as a postdoc coordinating and leading our Smart Cycling Futures PhD meetings, as a co-author working through article revisions with me, and as a co-supervisor helping me bring my PhD to completion – Anna Nikolaeva has provided clear and constructive advice that has helped me move forward with my work. And I will always be appreciative for the key role that my supervisor Ruth Oldenziel played not only in bringing the Smart Cycling
Futures research project into existence but also in committing herself to the ongoing work of building a community of cycling scholars that will long outlast that project. One of the reasons that I came to the Netherlands is because of my appreciation of the cycling culture that exists here. It has been an honor and a privilege to be a member of the community of scholars working to sustain that culture and I will always be grateful for having had the opportunity to be a part of this research.
Chapter 1: Introduction

In 2014, when I left San Francisco to attend a master’s program in the Netherlands, I looked forward to returning to a place where I could bike both safely and socially. I had lived in the Netherlands for a year as part of an undergraduate exchange program, and one of my favorite memories of that year was biking with my friends on short distance trips to classes and parties and longer weekend trips across the country. In the years after my exchange program, I became an active part of the cycling community in San Francisco but had grown tired of navigating unsafe roads and navigating social situations where I was the only one without a car. And indeed, when I returned to the Netherlands, the cycling routes were safe, and all my friends had bicycles. Still, I missed something from San Francisco. There, my social life had been built around cycling. Almost every Friday night, I went to either a Critical Mass event or a Bike Party ride. Critical Mass was a once a month chaotic and random ride through San Francisco with activists, tourists, nudists, and anyone who else enjoyed reclaiming the streets from cars by riding down the middle of the road and refusing to obey any traffic laws, an approach to cycling given tacit approval by our police escorts who allowed everything but access to the highway (at least once per ride, someone shouted, “Let’s take the bridge!” which never happened). Bike Party, occurring three times a month in different parts of the Bay Area, was a different type of ride. People were encouraged to obey traffic rules as they followed a set route, stopping for half hour breaks of socializing and dancing at various of parks, open spaces, and parking lots, and then following bikes trailing large speakers to the next public party spot. While the two evens had a different atmosphere, what they had in common was a group of individuals dedicated to enjoying, promoting, and sharing the joy of cycling in a publicly visible manner.

The people who organized and participated in the events were the same people who showed up at planning meetings to demand better bike infrastructure and who wrote blog posts complaining about unsafe intersections. These events were the places you could go to learn that the first Dutch style roundabout in the Bay Area was not actually going to give priority to people cycling or that the flexible bike lane system being developed to allow bicycle access to the Richmond Bridge was going to be implemented to order to prevent bicycle access to the bridge during key commuting hours. These events were the places where people heard about how the bicycle innovations being implemented around the Bay Area might not fully live up to their promises and just as importantly, where people could go to learn where to put pressure on elected officials for something better.

When I returned to the Netherlands, the entire cycling system was indeed far superior to San Francisco’s. Even though I had moved to a small city on the German border far from the major population centers, the town I lived in had things I had never seen before. An underground bike parking garage had a thin conveyer belt along the stairs that effortlessly pushed bicycles up to street level. The traffic signals at a major intersection had a phase where the all the bicycles could cross at one time. A bicycle highway connected the city center with campus. What I was not able to find was the sense of community built around both the joy of cycling
and the fight to establish its legitimacy as a form of transportation. There was of course a cyclists’ advocacy group, the Dutch Cyclists’ Union, that was built around membership and negotiations with elected officials, just as in San Francisco. The sense of collective identity that came from just riding a bicycle, however, was missing. And as impressed as I was at first with all the new things, I never used the mini-conveyor belt because I found more convenient places above ground to park my bike; I quickly became very annoyed with how long I had to wait for the all-cross bicycle signal; and even though I rode to campus regularly, the straight, wide bicycle highway directly along the train tracks was my least favorite route. These innovations were expensive, but they were not improving my cycling experience, and I wondered about the processes behind their implementation. It would be a few more years before I came across the quote, “For most Dutch, cycling is not remarkable enough to pay a lot of attention to,” (Stoffers, 2012, p. 93) or understand how the normalcy of Dutch cycling effects its governance. I understood quite quickly, however, that the angry activism that was shaping the cycling system in San Francisco was absent in the Netherlands. I only learned later that the Netherlands had a decades long history of disruptive cycling activism that led to this seemingly uneventful state of affairs. Other researchers had already begun to systematically analyze that process of normalization to understand what this historical activism meant for the development of the Dutch cycling system and what its absence meant for the future of cycling in the Netherlands.

In 1999, Adri Albert de la Bruhèze and Frank Veraart published a comprehensive comparative analysis of cycling culture that examined the different cycling histories and policies of four cities in the Netherlands and European cities outside of the Netherlands. They presented a four-factor model for understanding how different places developed different cycling systems: (1) urban landscapes and cycling distances; (2) urban alternatives to cycling; (3) cycling as traffic policy; (4) cycling’s cultural status (Albert de la Bruhèze & Veraart, 1999). In 2016, the two authors collaborated with Ruth Oldenziel and Martin Emanuel to produce an expanded and updated version of the work that covered 14 European cities. Cycling Cities: The European Experience expanded on the model and added another factor: (5) social movements and their impact. The research agenda that concluded the Cycling Cities book argued that more attention was needed for how cycling innovations develop and the role that they play in the promotion of cycling. Specifically, the cycling histories of the cities examined in the book suggested that traffic calming creates more successful cycling environments than traffic separation. The authors also suggested, however, that the development and implementation of the innovations that support these processes needed to be better understood (Oldenziel, Emanuel, Albert de la Bruhèze, and Veraart, 2016).

The dissertation presented here responds to that call for further research by examining aspects of the third (cycling traffic policy) and fifth (social movement) factors more closely. Specifically, it looks at the influence that people who cycle have on cycling innovations and the role of these innovations in traffic policy. The Cycling Cities project examined the factors conducive to creating high cycling rates and determined more research was needed on the role of cycling innovations in creating cities that support cycling. The research here focuses specifically on cycling innovations through an examination of their role in places that already
have high cycling rates. It demonstrates that a better understanding of how people who cycle influence cycling innovations leads to a better understanding of how to advance a transition to sustainable mobility systems where cycling plays a key role both in places with high cycling rates and places with lower cycling rates. The section that follows provides an explanation of the problem that this dissertation examines and presents the research questions used to address that problem, including an explanation of the key terms used in the research questions.

1 PROBLEM STATEMENT, RESEARCH QUESTIONS AND KEY TERMS

1.1 PROBLEM STATEMENT AND RESEARCH GAP

The urgency of the climate crisis requires a rapid transition to sustainable mobility systems and increasing cycling rates is seen as a means of advancing that transition (Bruno & Nikolaeva, 2020; Gössling, 2013; Gössling & Choi, 2015; Jensen, Cashmore, & Elle, 2017; Larsen, 2017; McAndrews, Tabatabaie, & Litt, 2018; Olmos et al., 2020). The Netherlands has the highest cycling rates in the world (Goel et al., 2021; Harms et al., 2014). Across the country, an average of 23% of trips of any distance are made by bicycle, including in the province with the lowest population density (CROW, 2012). With nearly half of the trips to the national rail system made by bicycle (KiM, 2019), the Netherlands has created a long-distance sustainable transportation system that provides an alternative to driving (Ploeger & Oldenziel, 2020). The Netherlands consistently implements cycling innovations that policymakers in other countries often advocate adopting to emulate the success of the Netherlands (Candelari, 2020; Chang, 2017; Koster, 2014; Pucher & Buehler, 2008; Rudick, 2021). The assumption that investments directed at cycling automatically lead to decreases in driving, however, ignores how automobility has adapted and has continued to be promoted throughout the period of advocacy for more sustainable modes of transportation (Schwanen, 2016; Wells & Xenias, 2015). This assumption also confuses correlation with causation, as the cycling rates in Dutch cities have not changed significantly in recent years and, like many cities in Europe, have remained relatively stable after a period of a steep decline 50 years ago (Oldenziel, Emanuel, Albert de la Bruhèze, et al., 2016; Reid, 2017) (see Figure 1).
This reflects the central problem identified and examined in this dissertation: cycling has the potential to play a key role in the urgent need for a transition to sustainable mobility systems; the role of cycling innovations in that transition, however, had not received much attention. As other countries look to the Netherlands for ways to increase cycling rates, policymakers in the Netherlands are looking for ways to increase its cycling mode share further, with a national goal of increasing cycling rates by 20% within the next 10 years (Tour de Force, 2017). In both low and high cycling contexts, efforts to increase cycling rates would benefit from a better understanding of the role of innovations in the cycling system and which innovations would be likely to make the most significant contribution to the advancement of transition goals. This dissertation addresses that research gap.

Scholars have already researched how people who cycle play a key role in creating cities where cycling is an accepted and common form of transportation and have established the role that people who cycle played in creating these cycling cities (Albert de la Bruhèze & Veraart, 1999; Oldenziel, Emanuel, Albert de la Bruhèze, et al., 2016). Theories of reconfiguration that have been used to understand the role of innovations in sustainability transitions, however, have only been applied to a very limited degree to cycling innovations (Canitez, 2019; Cass et al., 2018; Oldenziel, 2017; Schwanen, 2015). Further, this limited amount of literature on cycling innovations has not incorporated the analysis of critical mobility scholarship in order to better understand how cycling innovations are developed and implemented and whether or not these processes ultimately support people who cycle and help increase cycling rates. These insights from literature on the system of automobility (Urry, 2004), véломobility (Cox, 2019; Koglin, 2015) and the sustainable mobility paradigm (Banister, 2008a) provide additional knowledge on the role of cycling innovations. This knowledge is
particularly necessary in places with high cycling rates where the large number of people who cycle influence the form and type of innovations. These innovations are likely to be modelled by places with lower cycling rates that are looking for ways to transform their transportation systems but little has been published about the role of cycling innovations in mature cycling countries. This dissertation addresses this research gap by adding insights from critical mobility scholarship to the application of theories of reconfiguration in order to better understand the role of cycling innovations in the Dutch transportation system. The following section presents the research questions that guided the response to the issues defined in this problem statement.

1.2 Research Questions

To address the research gap described above, this dissertation asks the following question:

How can the insights from critical mobility scholarship be combined with theories of reconfiguration processes to allow for a better understanding of the role of cycling innovations in a mature cycling country, including how these innovations can be used to support people who cycle in order to advance a transition to sustainable mobility?

The research question is divided into four sub-questions, with each research chapter of the dissertation answering one of them and addressing a different aspect of the relationship between cycling innovations, theories of reconfiguration, and sustainability transitions. Chapter 2 provides a theoretical analysis, presenting an evaluation framework for analyzing the role of cycling innovations in sustainability transitions. Chapters 3 and 4 present specific case studies in detail, using them to illustrate the different roles of cycling innovations. Chapter 3 examines the role that people who cycled played in developing cycling innovations that challenged automobility in the Netherlands in the 1970s. Chapter 4 shows how cycling innovations intended to support people who cycle can be transformed by the system of automobility. Chapter 5 presents an approach for policymakers to develop cycling innovations that both support people who cycle and advance a transition to sustainable mobility systems: cycling innovations that keep people cycling through key life events could reduce the number of people who stop cycling, an approach to increasing cycling rates that has several advantages over convincing people to drive less and cycle more. The sub-question that each of these chapters answer and the relationship of that question to the central research question are presented in the remainder of this section, followed by an explanation of the key concepts that underlie these research questions.

Chapter 2 provides a broad examination of the first component of the central research question; it combines critical mobility scholarship with the application of the multi-level perspective and strategic niche management. This leads to the following question:

Sub-question 1: How can the sustainable mobility paradigm be combined with the theories of the multi-level perspective and strategic niche management to evaluate whether or not cycling innovations support people who cycle and advance sustainability goals in their context of implementation?
In answering this question, the chapter uses the sustainable mobility paradigm to define two distinct ways in which cycling innovations are implemented: some cycling innovations are implemented to support people who cycle in order to advance sustainability goals; other cycling innovations are implemented to manage existing cyclists in order to improve the system of automobility. The two chapters that follow examine each of these types of innovation in more detail.

Chapter 3 examines specific examples of cycling innovations, considering how the strategic niche management principle of protective space can be applied to social movements advocating for cycling. This chapter looks at the key role that innovations challenging automobility played in creating the present-day Dutch cycling system. It answers the following question:

Sub-question 2: In mature cycling countries, how can the strategic niche management principle of protective space be used to understand the role of historical social movements in the implementation of innovations that successfully challenged automobility?

Chapter 4 examines in detail the other role of people who cycle in the implementation of cycling innovations: It looks at how cycling innovations are sometimes implemented to manage cyclists in support of people who drive when there is a conflict between the two modes. In addresses this issue by answering the following question:

Sub-question 3: In mature cycling countries, how can the strategic niche management principle of protective space be used as a means of analyzing how collaborative governance processes can compromise innovations intended to challenge automobility?

The final chapter addresses the relationship between people who cycle and cycling innovations in the context of sustainability goals. It answers the following question:

Sub-question 4: How can social practice theory be used to demonstrate the potential benefits of implementing innovations directed towards people who cycle?

Answering the first sub-question involves developing a general framework for applying critical mobility theory to theories of reconfiguration in order to evaluate whether or not cycling innovations serve people who cycle and advance a sustainability transition. Answering sub-questions 2 and 3 involves directly applying different transition theories to cycling innovations in order to answer the first part of the central research question, understanding the role of cycling innovations in a mature cycling country. Answering sub-question 4 addresses the second part of the overarching research question: how the novel application of a theory of reconfiguration can allow for a better understanding of the full range of cycling innovations capable of supporting sustainability transitions.
1.3 Key Terms
The central research question and the sub-questions contain several key terms that require explanation: people who cycle, mature cycling countries, automobility, véломobility, innovation, and sustainability transitions. The paragraphs that follow describe how these terms are used within the dissertation and what their relevance is for the central research question.

The phrase “people who cycle” purposely appears throughout this dissertation to describe people who use the bicycle as a form of transportation. Most studies on cycling use the term cyclists. On the other hand, in innovations studies, the people that adopt an innovation are generally referred to simply as users (Oudshoorn & Pinch, 2003). This dissertation often refers to the body of literature that discusses the role of users in the development and upscaling of innovations. The term ‘people who cycle,’ however, takes the place of both ‘users’ and ‘cyclists’ in this research. This is done in the framework of person-first language (Crocker & Smith, 2019). Person first language moves away from a focus on a particular identity and towards a focus on the person, emphasizing that people who cycle have an identity beyond riding a bicycle and may also sometimes drive, walk or take transit. At the same time, the term is more specific than the general term “users,” as this dissertation focus specifically on cycling innovations. “People who cycle” makes clear that the dissertation is not about the adoption of a certain identity (‘cyclist’) but the increased use of a sustainable mode. Just as innovations literature describes the different roles that users can play in innovations processes (Oldenziel & Hard, 2013), this dissertation describes the different roles that people who cycle can play in relation to cycling innovations. The second chapter looks at the role of people who cycle in the transportation system and their relationship to policymakers that implement innovations to support them and innovations to manage them to improve the efficiency of the system of automobility. The third chapter looks at how people who cycle can also be activists that support the development and implementation of cycling innovations. The fourth chapter looks at people who cycle in their role as citizens and stakeholders in collaborative governance processes with policymakers. The fifth chapter looks at people who cycle in their role as reproducers of social practices and the implications of social practice theory for how policymakers can approach cycling policy.

The term “mature cycling country” is used throughout this dissertation. The research presented here focuses primarily on the Netherlands, as its high cycling rates make its cycling innovations of interest to the rest of the world, while the underlying relationship between these high cycling rates and the cycling innovations that it implements is not well understood. Harms et al. (2014) use the term ‘mature cycling country’ to differentiate between research on building a cycling system in places with a limited number of people who cycle and a limited amount of infrastructure and research on the complexities of the cycling system in places where the cycling mode share is high and where building cycling infrastructure is a standard part of planning practice. Since then, other scholars have used the term to describe places where cycling is considered a normal daily activity (Dekker, 2021) or where cycling is one of the most common forms of transportation (Petzer, 2021). In this dissertation, the term
“mature cycling country,” is used to signify high cycling contexts: places where cycling has a significant history and the number of people who currently cycle is sufficiently large that the cycling system is significantly shaped by two different processes: changes to the cycling system that come from the demands of people who cycle and changes to the cycling system that come from pressure to manage people who cycle in order to accommodate other modes. The central research question addresses the role of cycling innovations in both processes.

The research in this dissertation looks at people who cycle primarily in the context the Netherlands, as its high cycling rates make its cycling innovations of interest to the rest of the world, while the underlying relationship between these high cycling rates and the cycling innovations that it implements is not well understood. In describing the Netherlands, this dissertation uses the term ‘mature cycling country’ Harms et al. (2014) to differentiate between research on building a cycling system in places with a limited number of people who cycle and a limited amount of infrastructure and research on the complexities of the cycling system in places where the cycling mode share is high and where building cycling infrastructure is a standard part of planning practice (2014). Since then, other scholars have used the term to describe places where cycling is considered a normal daily activity (Dekker, 2021) or where cycling is one of the most common forms of transportation (Petzer, 2021). In this dissertation, the term “mature cycling country,” is used to signify high cycling contexts: places where cycling has a significant history and the number of people who currently cycle is sufficiently large that the cycling system is significantly shaped by two different processes: changes to the cycling system that come from the demands of people who cycle and changes to the cycling system that come from pressure to manage people who cycle in order to accommodate other modes. The role of cycling innovations in both processes is a key component of the central research question.

The sub-questions of this research use the term ‘automobility’ to describe the relationship between cycling innovations and elements that are supportive of driving. Urry (2004) has defined the system of automobility as the globally dominant car system that exerts influence over society (Urry, 2004). Even as a mature cycling country, the Netherlands is also a part of this system of automobility. While cycling is well established within the Netherlands, and the national government spends tens of millions of Euros yearly on cycling infrastructure, it generally invests 10 to 20 times that amount in highway infrastructure (Dekker, 2021). Even in mature cycling countries, as researchers have argued—and this dissertation concludes—cycling innovations related to both infrastructure and policy are not exempt from the strong influence of automobility (Petzer et al., 2021).

The term ‘véломobility’ is used in this research to describe the system of cycling. Related to the term automobility, which includes the entire socio-technical system associated with the car, the system of véломobility refers not only to the bicycle itself but also to any element that makes cycling as a form of transportation possible (Behrendt, 2016; Horton et al., 2007). The innovations analyzed in this dissertation, therefore, include examples of policy innovations, infrastructure innovations, design innovations, and governance innovations that affect, both
positively and negatively, the system of vélocimobility. The theory section goes into further detail about the systems of auto- and vélocimobility.

The research presented here uses the term ‘innovation’ in a very broad sense. While innovation can be defined in different ways, this dissertation uses the definition presented in an overview of the academic writing on innovation: “Innovation is the creation and implementation of new processes, products, services and methods of delivery which result in significant improvements in outcomes, efficiency, effectiveness or quality” (Taylor, 2017, p. 131). This definition is useful here for two reasons. The first is that the definition encompasses not only developments in technology, but also developments in infrastructure, policy, governance, and design; all these innovation types appear in this dissertation. The second reason is that it focuses on improved outcomes, reflecting this dissertation’s examination of the effects of cycling innovations on sustainability transition goals. While this dissertation uses a broad definition of innovation, it uses the term in a directed manner: the theoretical frameworks on which the arguments of this dissertation are based come from the scholarship on innovation. As described in more detailed in the next section, the insights on cycling systems found in this dissertation are largely based on the application of theories on how innovations are developed, implemented, and upscaled.

The central research question focuses on a transition to sustainable mobility systems. Cycling has received attention for its ability to allow people to travel “in an affordable, healthy, safe, resource-efficient and environmentally friendly way” (Pospischil & Mailer, 2014, p. 81). While the definition of sustainability is highly contested (Köhler et al., 2019), sustainable transport scholars generally focus on issues of ecology, equity, and economy to understand how transportation systems can meet people’s travel needs while minimizing their environmental impact (Holden et al., 2013a, 2019; Schiller & Kenworthy, 2017). A large body of sustainable transport literature argues that replacing driving trips with cycling trips would help meet sustainable mobility goals (Banister, 2008; Jensen et al., 2017b; Meschik, 2012; Pucher et al., 2010; Silva et al., 2019). When this dissertation refers to a transition to sustainable transportation systems where cycling plays a key role, it is referring to advancing a shift in the mode share away from driving and towards cycling. Specifically, as described in the theory section, it uses the principles of the sustainable mobility paradigm (Banister, 2008a) that advocate for deprioritizing motorized transport and investing in developing cities that encourage walking and cycling as the least energy intensive forms of travel.

Each of the terms described above appear throughout the dissertation to answer the central research question and sub-questions. The sections that follow present the theoretical frameworks through which these questions were approached, the methods used to address each specific question, and a general summary of each of the chapters.
This dissertation draws primarily on theories of reconfiguration and critical mobility scholarship its analysis. Insights from critical mobility scholarship – the systems of automobility, vélomobility and the sustainable mobility paradigm – allow existing knowledge on the dynamics between different modes to be included in the reconfiguration analysis. The application of different theories of reconfiguration – the multi-level perspective, strategic niche management, and sustainable mobility paradigm – allow for the examination of different aspects of the role of cycling innovations in the transition to sustainable mobility. The multi-level perspective provides a broad framework for understanding the development and implementation of cycling innovations; strategic niche management provides a framework for understanding the changes that cycling innovations undergo during the implementation process; and social practice theory provides a framework for understanding the role of people who cycle in a potential reconfiguration of the transportation systems. Each chapter of the dissertation combines critical mobility scholarship with one or more theories of reconfiguration in either a novel combination or novel manner to better understand the role of cycling innovations in sustainability transitions. The remainder of this section describes the critical mobility scholarship that informs this dissertation followed by an overview of the different theories of reconfiguration processes used in the individual chapters (see Figure 1). The section concludes with a discussion of how each of the theories relate to each other, how they already been applied to cycling, and how the dissertation builds on this research to make a novel contribution to the understanding of the role of people who cycle in the development and implementation of cycling innovations.
2.1 **Critical Mobility Scholarship**

Over the past several decades an increasing amount of attention has been given in social sciences literature to how issues related to mobility influence all aspects of modern society. Sheller and Urry (2006) referred to this as ‘the new mobilities paradigm’ and the broad set of literature included within this mobility turn has included a number of writings by prominent scholars on the impact of the automobile on people’s conceptions of time and space and the power dynamics inherent in different forms of mobility (Cresswell, 2010a, 2010b, 2012; Sheller & Urry, 2000; Urry, 2004). These insights on the power dynamics created by the automobile have been taken up by a group of critical vélocimobility scholars who have specifically examined the influence that the automobile has had on how people conceive of and engage with cycling as a form of transportation (Cox, 2019; COX, 2019; Kingham, 2008; Spinney, 2016; Spinney, 2022). Other critical mobility scholarship, such as the sustainable mobility paradigm (Banister, 2008a), has taken the dynamics of automobility and vélocimobility directly into account when defining the characteristics of a sustainable mobility system. The sections below provide a brief overview of the critical mobility scholarship relevant to this dissertation and how it informs the chapters that follow.

2.1.1 **The System of Automobility**

In “The City and Car,” Sheller and Urry (2000) argued that the motor car had reconfigured urban life, creating an automobilized times-space that involved new ways of dwelling, travelling, and socializing. Urry (2004) expanded on this by arguing that the automobile had taken on a dominant character in society and this dominance could be understood through six characteristics that, when taken together, formed the system of automobility. These six characteristics include the car as a central manufactured object of industrial companies; as a prominent item of individual consumption that signifies status for its owner; as a complex of technical and social connections surrounding all of the supportive infrastructure (roads, gas stations, repair facilities, advertising campaigns, house architecture) necessary for the car to function effectively; as the dominant form of mobility that changes how people organize their lives and exerts an influence over all other forms of mobility; as a cultural element that with a significant place in literary and artistic representations of what it means to be a citizen participating in society; and as the source of a considerable amount of environmental resource-use.

This dissertation discusses cycling innovations within the context of this dominant system of automobility, noting that even in a mature cycling country such as the Netherlands, where cycling rates are considerably higher than many of its neighboring countries, most trips are still taken by car in most cities (Oldenziel, Emanuel, Albert de la Bruhèze, et al., 2016). Petzer et al. (2021) has specifically argued that cycling infrastructure in the Netherlands is always in competition with automobility, including as an element of environmental resource use the disproportionate amount of street space that automobiles require to operate effectively and efficiently. This dissertation, therefore, adopts this assertion that the system of automobility exerts an influence over all other modes. Throughout the chapters, when discussing cycling innovations, this dissertation examines those innovations within the context
of the system of automobility. It notes the ways in which the automobile’s dominance effects their implementation and the instances where certain elements and conditions allow the actors behind cycling innovations to challenge elements of the dominance of the system of automobility.

2.1.2 Critical Vélomobility Scholarship
Following the work of Urry (2004), other scholars have examined the implication of automobility’s dominance specifically for the advancement of cycling as a form of transportation. These critical mobility scholars have analyzed cycling’s contested nature and the influence that automobility has on it (Cox, 2019; Freudendal-Pedersen, 2015a; Koglin & Mukhtar-Landgren, 2021). These scholars take the idea from mobility studies that “mobilities are both productive of social relations [that involve the production and distribution of power] and produced by them” (Cresswell, 2010b, p. 21), and apply these concepts of power directly to the system of cycling. Koglin & Rye (2014) argue specifically that more bicycle friendly cities can be created through an improved theoretical understanding of the politics of vélomobility that begins with an analysis of the social/power relations in urban traffic spaces. The chapters of this dissertation adopt this perspective and consistently note the configuration and influence of the automobility regime when describing how cycling innovations are developed and implemented. Even mature cycling countries with their relatively high cycling rates have a contested and complicated relationship between vélomobility and automobility (Cox & Koglin, 2020; Freudendal-Pedersen, 2015a, 2015b; Henderson & Gulsrud, 2019). This dissertation uses critical vélomobility scholarship to analyze how conditions within mobility regimes with established cycling cultures can sometimes allow for the development and implementation of cycling innovations that challenge automobility and sometimes result in cycling innovations that support automobility.

2.1.3 The Sustainable Mobility Paradigm
The central research question of this dissertation involves the transition to sustainable mobility systems. Answering this question requires a framework for sustainable mobility. The sustainable mobility paradigm provides a useful tool for analyzing the role cycling innovations in a sustainability transition: it addresses the role of cycling in advancing sustainability goals.

The sustainable mobility paradigm (SMP) presents an approach for moving away from traditional car centered transport planning and towards sustainable mobility systems (Banister, 2008). While sustainability is often a secondary concern for other forms of transportation planning (Kemp et al., 2012), cycling is one the most sustainable forms of transportation (Pospischil & Mailer, 2014). As such it often plays a key role in plans to advance a transition to sustainable mobility systems (Karanikola, Panagopoulos, Tampakis, & Tsantopoulos, 2018; Pospischil & Mailer, 2014; Pucher & Buehler, 2017). The sustainable mobility paradigm is useful in understanding which cycling investments will best support this transition: it provides a framework for understanding different approaches to transportation planning and the relationship of these approaches to sustainability goals.
The SMP does not advocate simply shifting resources from unsustainable to sustainable modes. Rather, the paradigm addresses the logical outcomes of following two different and opposing approaches, what Bannister (2008b) calls the conventional and alternative approach. The conventional approach considers travel a derived demand where the goal of transportation planning is to minimize travel times with a strong focus on reducing car congestion. These investments, by allowing efficient car travel over long distances, promote sprawling cities and car dependence. The sustainable mobility approach, on the other hand, focuses on travel as a valued activity, where the number of undesirable trips is reduced or eliminated: planning is directed towards creating medium density communities with reasonable and reliable travel times that allow for public transport, walking, and cycling.

The approach described by the sustainable mobility paradigm covers a broad range of elements related to land use and transportation planning. This dissertation focuses on the elements that are relevant to cycling innovations as a tool for advancing sustainable mobility. Specifically, the sustainable mobility paradigm argues for moving away from motorized transport and placing the highest priority on the least energy intensive forms of travel, namely pedestrian and cyclist transport. Practically, this means slowing movement down instead of finding ways to speed up car traffic. It also means a greater focus on integrating people and traffic instead of taking a traffic segregation approach to maximize the efficiency of the car system. The dissertation uses these specific principles from the sustainable mobility paradigm to discuss and analyze the impact of cycling innovations on sustainability goals. Applying the sustainable mobility paradigm to the evaluation of cycling innovations allows for a foregrounding of the planning approach that underlies the implementation of an innovation. This removes the assumption that an innovation focused on a sustainable mode must support sustainable goals and allows for an examination of the relationship between the innovation and the development of sustainable mobility systems.

Using the paradigm as a benchmark for sustainability comes with both advantages and limitations. The sustainable mobility paradigm presents clear criteria for what constitutes a sustainable approach to transportation planning. For this reason, it makes a useful analytical tool that contains multiple elements directly relevant for cycling policy. The sustainable mobility paradigm, however, is based on a specific vision of reducing sprawl and developing more compact cities to reduce car dependency (Banister, 2006). There are also other frameworks for evaluating sustainability. Holding, Linnerud & Banister (2013) have developed a means for evaluating progress towards sustainable passenger transport based on four metrics: ecological sustainability, satisfaction of basic human needs, intragenerational equity, and intergenerational equity. This evaluation model for overall sustainability is more comprehensive and broader than the sustainable mobility paradigm, but it also focuses on quantitative metrics for measuring progress. The dissertation focuses on the values that underlie the development and implementation of cycling innovations. Such qualitative elements are better analyzed through the lens of the sustainable mobility paradigm. While the quantification of the effects on sustainability goals is outside the scope of this dissertation, it would be an important area for future research and one that would involve using a different framework for evaluating sustainable transport. Nevertheless, the sustainable mobility
The critical mobility scholarship described above provides a number of analytical lenses through which to understand the relationship between automobility and vélocimobility, but this scholarship does not directly address innovations and their role in transition processes, a key element of the central research question. Addressing this transitions element requires the application of theories of reconfiguration processes. Geels et al. (2015) have used the label ‘reconfiguration’ to collectively describe theories of change in both socio-technical systems and social practices. They note that transitions theories such as the MLP and social practice theory both “investigate reconfigurations from different angles” (Geels, 2015, p. 6), with the MLP often being applied to the development process and social practice theory being used to understand how people incorporate innovations into their daily life. This dissertation examines both the development and use of multiple cycling innovations and does so through the lens of three of these theories of reconfiguration: the multi-level perspective, strategic niche management and social practice theory. Each of these theories examine transformation processes that can lead to ecological and social sustainability, and while they differ in how they conceptualize these processes, they each consider the role of multiple actors and their involvement in complex systems and practices (Keller et al., 2022).

One of the foundational works in the development of a comprehensive theory of sociotechnical change, Wiebe Bijker’s Of Bicycles, Bakelites, and Bulbs: Toward a Theory of Sociotechnical Change (1997) used the development of the bicycle to serve as a historical case on which it built the theory. This dissertation makes use of different theories of reconfiguration that were developed in part in response to Bijker’s work. First, the multi-level perspective (MLP) is used as a broad analytical tool for understanding the development and implementation of cycling innovations. Second, Strategic Niche Management (SNM) is used to understand the implementation pressures surrounding specific cycling innovations and how they develop and change in response to the environments in which they are implemented. Finally, social practice theory (SPT) is used to understand how directing innovations towards people who already cycle can advance a sustainability transition. The sub-sections that follow provide an overview these theories and their role in the dissertation.

2.2.1 The Multi-Level Perspective (MLP)

The role of cycling innovations in transition processes is another key element of the central research question. One of the more widely used frameworks for conceptualizing these processes is the multi-level perspective (MLP) (Fraedrich et al., 2015; F. W. Geels, 2005; Kenger & Schot, 2016; Köhler et al., 2019; Voss et al., 2009). The MLP has been described as “a conceptual tool with the advantages of scope and generalizability... that has been used to explain past and contemporary transitions” (Lachman, 2013, p. 271). Because it is a broadly applicable transitions theory that has already been used to address sustainability transitions in
transportation (Geels, 2012), the MLP provides versatile framework for analyzing the processes through which cycling innovations developed and are implemented.

As outlined in the second chapter of the dissertation, the MLP describes transitions as non-linear processes that come about through the interactions between three levels: niches, socio-technical regimes, and the broader socio-technical landscape (Geels, 2012; Geels & Schot, 2007). Socio-technical regimes are defined by the set of written and unwritten rules followed by companies, government actors, end-users, and other actors operating where innovations must compete. Niches, which can be initiated by regime actors or non-regime actors, are the source of innovations that depart from existing practices; they can potentially originate from groups such as research and development projects, start-ups or government subsidized experimental programs. The landscape is the broader physical and social context beyond the control of individual actors (Geels, 2012; Geels & Schot, 2007). Rather than focusing exclusively on technology or economics, the MLP takes an actor-based approach and looks at the interactions between groups within and across the different levels (Kemp et al., 2012).

As a broad model for transition processes, the MLP has been applied to understand how to advance sustainability transitions in the areas of energy supply, water supply, sanitation, agriculture, and transportation (Markard et al., 2012). This dissertation applies the MLP to better understand the role of cycling innovations in sustainability transitions. To accomplish this, the dissertation focuses on the areas of the theory most relevant to understanding transition processes related to cycling.

The MLP discusses socio-technical systems, the entire “configuration of technologies, services, infrastructures, regulations, and actors” (Kenger & Schot, 2016, p. 599) that are associated with a technology. This concept is used to clarify that this dissertation is not addressing only the bicycle as an object but the entire system of vélocimobility. For cycling, this includes user practices, industry, infrastructure, technology, regulations and policies, culture and symbolic meanings, knowledge, and the built and natural environment (Canitez, 2019). The dissertation also draws significantly on the landscape and regime concepts of the MLP to illustrate the different ways in which cycling innovations can influence the transportation system. It uses the landscape concept to illustrate the role of specific historical and geographical factors in the advancement of cycling innovations. The regime concept is used to analyze the relationship between cycling and the dominant of regime of automobility in transportation systems.

The MLP is used most prominently to address two of the dissertation’s four sub-questions. First, for the sub-question that provides a general overview of how people who cycle can drive cycling innovations. Here, concepts from the MLP help illustrate the relationship between innovations and different modes within the transportation system. And second, the MLP plays a role in answering the sub-question that addresses the specific roles that people who cycle can play in advancing innovations that support sustainability transitions. There, the MLP is used to discuss social movements as a landscape factor influencing the development of historical and present-day cycling innovations.
The MLP has both strength and limitations. While the MLP has been criticized for its lack of precise concepts and overly complex theoretical structure (Lachman, 2013), it has been highly influential in the work of others writing about cycling, sustainability, and innovations (Cass, Schwanen, & Shove, 2018; Geels, 2018; Marletto, 2014; Oldenziel, 2017; Schwanen, 2015). Other scholars have consistently referenced the MLP in relation to cycling but only a limited amount of scholarship exists specifically apply the MLP to cycling (Canitez, 2019; Geels, 2012). This dissertation provides a critical examination of how the MLP has been applied to cycling, including the development of a new approach to its application. The analysis of how the concepts are applied to cycling provides a starting point for clarifying the complexities of the MLP in relation to cycling, a necessary discussion if future scholars are to continue to use the MLP to analyze process related to cycling.

While it has its limitations, the flexibility of the MLP makes it a useful tool for discussing innovations related to policy tools, design elements, and urban concepts. This analysis required a transitions theory broad enough to discuss different forms of innovation with the same language, which the MLP provides. The metaphorical ecosystem language for which the MLP has been criticized (Smith, Voss, & Grin, 2010) became a strength here, allowing the same concepts that have been employed to discuss technological innovations (Geels, 2007; Moradi & Vagnoni, 2018; Tyfield, 2014) to be applied to policy innovations.

2.2.2 Strategic Niche Management (SNM)

While the MLP is a useful framework for understanding broad transitions processes, the transitions theory of Strategic Niche Management (SNM) is better suited for addressing the role people who cycle play in advancing specific cycling innovations. While SNM shares concepts with the MLP, its application has a more directed focus (Lachman, 2013). SNM looks at the challenges of managing innovations to support upscaling processes and how innovations may change through those management processes (Schot & Geels, 2008). This is directly relevant for this dissertation, as it contains multiple examples of cycling innovations that were developed to advance a sustainability transition but do not function entirely as intended after being transformed by the demands of automobility. SNM theory provides an analytical tool for explaining the differences between the conceptual intent of these innovations and their real-world implementation.

Strategic niche management (SNM) literature describes how each of the elements that comprise a socio-technical system have an influence on the adoption of an innovation when it is in the early stages of development (Smith and Raven, 2012). Strategic niche management scholarship argues that government and industry play a key role in creating spaces that allow innovations to succeed, protecting them from selection pressures when they are still in a development stage (Barrie et al., 2017; Smith & Raven, 2012; Verhees et al., 2012). These selection pressures can include barriers created by existing industry structures, technical standards, established research paradigms, market rules, user routines, government regulations, and cultural values (Smith & Raven, 2012). Particularly for innovations intended to advance sustainability goals, both public policies and private initiatives may be necessary to develop, improve and adapt innovations until they can overcome these selection pressures.
While strategic niche management often focuses on the development of technological innovations, its principles have been applied to policy innovations as well (Ieromonachou et al., 2004).

The dissertation applies the elements of strategic niche management that are most relevant to cycling infrastructure and policy innovations, particularly two principles that are related to user practices. The principle of fit-and-conform empowerment describes how an innovation will have a greater chance of success if users adapt the innovations to fit with their existing practices and preferences. The principle of stretch-and-transform empowerment describes situations in which the innovation succeeds by changing existing practices and preferences. (Smith and Raven, 2012). The dissertation uses these two principles to argue that cycling innovations may need to adapt in different ways in places with low cycling rates compared to places with high cycling rates, with these adaptations based on an understanding of user practices.

The dissertation also uses the SNM concept of protective spaces to argue that the work done by activists to support sustainability advancing innovations protects those innovations in their early stages from groups opposed to their implementation. In additional to using SNM principles to argue that social movements provide implementation protection in the form of political pressure and support, the dissertation also uses SNM to argue that these same social movements can support the successful upscaling of sustainability innovations through their active engagement with the development, adaptation, and implementation processes.

SNM has strengths and weaknesses in helping to understand the role of people who cycle in shaping cycling innovations. SNM’s attention to the importance of user practices in innovation implementation is one of its greatest strengths as a tool for understanding transportation innovations. One of the limitations in drawing extensively on SNM in combination with the MLP, as this dissertation does, is the complex and sometimes opaque relationship between the two theories. While the MLP and SNM share some of the same conceptual language and were developed out of some of the same evolutionary theories (Lachman, 2013), SNM, with its focus on managing innovations rather than conceptualizing their development processes, is based on a set of literature that is distinct from the MLP (Caniëls et al., 2006; Ieromonachou et al., 2004; Raven et al., 2010; Schot & Geels, 2008). Using them together requires keeping this distinction clear.

2.3 SOCIAL PRACTICE THEORY (SPT)

The final sub-question of the dissertation focuses primarily on a specific element of the central research question: how innovations can be used to support people who cycle in order to advance a transition to sustainable mobility. Social Practice Theory (SPT), with its attention for the role that routine behaviors play in shaping change processes, provides a means for demonstrating the importance of people who cycle in a long-term transition to sustainable mobility systems. SPT theory was chosen for the section of the dissertation that addresses how existing cyclists can advance transition processes because the focus of this section is not
on specific cycling innovations but the relationship between cycling innovations and the maintenance of cycling practices. The focus of social practice theory on how practices such as cycling can grow and decline serves as a useful analytical tool for this part of the dissertation. SPT has been useful to other scholars that look at the role of cycling in sustainability transitions, as the theory allows to analyze the “actions, habits and routines of daily experience” (Watson, 2012, p. 490) of those who cycle. The SPT framework defines three primary elements that constitute a practice as the tools for this analysis: meanings (ideas, aspirations, values, and symbolic interpretations); competencies (shared abilities and practical knowledge); and materials (physical things, including technologies, objects, and infrastructure) (Shove et al., 2012; Strengers & Maller, 2014). These concepts form the foundation of the dynamics of social practices, including their development and change over time (Reckwitz, 2002; Shove and Pantzar, 2007; Shove et al., 2012). Because of the interconnected nature of the meanings, materials, and competencies that constitute a practice, more than a change in attitude is required for a change in practices (Evans, 2012; Genus and Jensen, 2019; Shove, 2010). SPT scholars suggest that the most effective focus for a policy oriented towards behavior change is an examination of “the social and collective organization of practices – broad cultural entities that shape individual’s perceptions, interpretations and actions within the world” (Hargreaves, 2011, p. 79). This dissertation looks at how cycling innovations could advance policy goals related to sustainability transitions, focusing specifically on the role played by the social practice theory concepts of recruitment and defection (Shove et al., 2012). A social practice grows when more people are recruited into it than defect from it and declines when more defections occur than recruitments. These concepts are used to answer the final sub-question and demonstrate the potential for increasing the mode share of cyclists through a focus on the maintenance of existing cycling practices.

Social practice theory is particularly strong in bringing attention to the role of everyday routines in reconfiguration processes; it provides a model for understanding the complex and interconnected nature of practices and how they can change. The SPT is explicitly not intended as a guide for how to manage change (Shove & Walker, 2007a, 2010). Its strength lies in its ability to represent complex relationships and to examine those relationships over time, with an historical examination of the rise, decline and persistence of cycling being one of the more prominent cases in developing the theory (Shove, 2012). This makes it well suited for examining the future of cycling practices in a country with high cycling rates. The final chapter uses social practices theory to suggest how the exclusive focus on changing the practices of people who drive is unlikely to succeed in achieving long-term mode change and the practices of existing cyclists remain undervalued. While social practice theory concepts help to argue that maintaining cycling practices can lead to a mode shift, specifying the interventions on how to maintain and implement cycling rates are outside its domain. The theory provides a starting point for better understanding the challenges and how to approach them. It cannot, however, be applied to modelling the effectiveness of a particular set of solutions. The conclusion discusses ways that future research could address this limitation.
2.4 THE RELATIONSHIP BETWEEN THE THEORETICAL FRAMEWORKS

This dissertation draws primarily on critical mobility scholarship and theories of reconfiguration processes for its analysis. While each of the theories in this dissertation have a relationship with each other, they also draw on distinct and in some cases opposing bodies of literature. Scholars that examine transition theories from a mobilities perspective have argued that transition literature focuses too much on the role of technology in transitions and needs to better acknowledge the role of non-technological forces such as changes in practices and meanings and the role of social movements in advancing change processes (Temenos et al., 2017). This dissertation draws on critical mobility scholarship in order to address those criticisms. It uses the system of automobility and critical vélosmobility scholarship, both of which draw on sociological perspectives (Cox, 2019; Sheller, 2014). It does so to move the focus away from the technological aspects of cycling innovations and more closely examine the role that people who cycle play in the development and implementation of cycling innovations. While the sustainable mobility paradigm (Banister, 2008a) comes from perspective of transportation planning rather than sociology, it connects with critical mobility scholarship in the way in which it argues for a reevaluation of how mobility is traditionally conceptualized and mobility projects are evaluated, including challenging concepts such as the importance of minimizing travel costs and the assumption that travel is a derived demand. While scholarship on automobility and vélosmobility are used in this dissertation to draw attention to the social challenges of increasing cycling rates, the sustainable mobility paradigm is used to establish why implementing cycling innovations that challenge automobility would support a transition to sustainable mobility systems. The SMP’s argues directly for the inclusion in planning of the social principles described in critical mobility scholarship, demonstrating how prioritizing people who cycle over people who drive can be a key element in advancing sustainable mobility goals. While leading transitions scholars have described the SMP as “the best attempt to define sustainable mobility” (Kemp et al., 2012, p. 10), these scholars did not use the framework in their research: they focused on automobility, a system in which sustainability concerns are often secondary. Cycling scholarship, policy, and practices, however, are often directly mobilized in terms of sustainability (Blickstein & Hanson, 2001; Dalpian et al., 2015; Horton, 2006; Karanikola et al., 2018; Pospischil & Mailer, 2014; Pucher & Buehler, 2017), making the SMP a useful tool that had yet to be applied to cycling innovations.

The insights from critical mobility scholarship are applied to three related but distinct theories of reconfiguration in order to analyze the role of cycling innovations in transition processes: the multi-level perspective (MLP), strategic niche management (SNM) and social practice theory (SPT).

While SNM uses many of the same concepts as the MLP (Lachman, 2013), SNM has a more directed focus, examining upscaling processes and the challenges that accompany them (Schot & Geels, 2008a). The multi-level perspective provides a tool for analyzing the role of different actors in a mobility transition that involves a shift from driving to cycling; strategic niche management allows for a similar analysis at the level of specific innovations.
The MLP has only been applied to cycling to a limited degree, receiving either a brief mention in the application of MLP to transportation (Geels, 2012) or has been referenced without a significant analysis of the role of cycling in transportation systems (Canitez, 2019; Cass et al., 2018; Geels, 2018; Marletto, 2014b; Oldenziel, 2017; Schwanen, 2015). This dissertation makes a unique contribution through its attention to how the MLP can be applied to cycling by focusing on how the regime concept helps in understanding the role of cycling within the larger system of mobility.

Similarly, SNM had only been applied to a limited degree to transportation policy, with congestion pricing having been analyzed using an adapted form of SNM, strategic policy niche management (Ieromonachou, Potter, & Warren, 2006; Petros Ieromonachou et al., 2004). This dissertation applies this concept to innovative cycling policies for the first time to analyze how cycling policy innovations can be altered in different implementation contexts; how social movements can function as a form of protective space; and how a failure to create adequate protective spaces within specific governance processes can hinder the upscaling potential of cycling innovations.

Social practice theory differs substantially from the MLP and SNM in its approach; it focuses on the role those daily routines play in change processes rather than on the larger trajectory of particular innovations. Scholars have noted, however, that the MLP and SPT, as models for reconfiguration processes, share many fundamental elements (Geels, McMeekin, Mylan, & Southerton, 2015; Liedtke, Hasselkuß, Speck, & Baedeker, 2017). This includes the conceptualization of co-evolving heterogeneous elements within their analysis; the importance of the tension between stability and change; and the process orientation of both theories (Geels et al., 2015). There are also significant differences between the theoretical approaches as well, with the MLP focusing on a hierarchy of nested systems and SPT describing a non-hierarchical system of interlinked elements of practice (Keller et al., 2022). Shove and Walker (2007b), writing from a social practice perspective, have been highly critical of transitions scholarship, arguing that its claims about the ability to steer transitions in particular directions are based on unfounded assumptions of consensus and an inadequate examination of issues related to conflict and inequality. Because of the differing theoretical foundations and tensions between the MLP and SPT, they are not applied together in this dissertation. Rather, the practice approach of SPT is applied in a chapter separate from those that use the systems approach of MLP and SNM in order to demonstrate how a theory of reconfiguration that is sometimes seen as being critical of transitions scholarship can be used to better understand the role of cycling innovations in increasing cycling rates.

Unlike the MLP and SNM, social practice theory (SPT) had already been used to analyze the reconfiguration of cycling systems (Cass & Faulconbridge, 2016; Watson, 2012). The novel contribution of this dissertation is therefore not the application of SPT to cycling, but how it is applied. Previous studies focused entirely on recruitment, examining the kind of policy choices that might result in people changing from unsustainable to sustainable transportation practices. The research presented here demonstrates how innovations meant to maintain existing cycling practices can also lead to a transition to sustainable mobility systems.
As described above, each chapter of the dissertation combines critical mobility scholarship with one or more theories of reconfiguration in either a novel combination or novel manner to better understand the role of cycling innovations in sustainability transitions. The section that follows describes the specific methods used in the application of these theories as analytical tools.

3 METHODS

3.1 METHODS OVERVIEW

As this research focuses on the relationship between people and processes, it takes a qualitative approach, using media reports, policy documents, and interviews to analyze various social actors and processes involved with cycling innovations. Each sub-question of the central research question involves different sets of theories, actors, and processes, and therefore each sub-question is best answered with a different combination of qualitative methods.

Chapter 2 combines a literature review and theory analysis, explicitly establishing the relationship between theories of reconfiguration and critical mobility scholarship that will be used throughout the dissertation. Chapter 3 and 4 apply theories of reconfiguration to specific examples of cycling innovations and rely on methods that help to allow for the detailed analysis of particular cases. Specifically, the third chapter uses semi-structured interviews to develop a historical account from a present-day perspective, allowing key actors to reflect on the long-term impact of their own actions. In the fourth chapter, a case study based on interviews, government policy documents, newspaper reports, consultancy studies, community meeting notes, and direct observation reconstructs how an innovation shifted purpose when implemented in a context very different from the one for which it was developed. Chapter 5 chapter moves away from specific innovations and looks at the broader implications of different policy approaches to cycling innovation through a comparative policy analysis.

The sections that follow provide a more detailed account of the methods used in each chapter. Each section begins with the sub-question addressed in the chapter and a short summary of the central argument of the chapter. The section then describes the methodological approach used to build the argument that is presented and concludes with a discussion of the strengths and limitations of each of the qualitative methods.

3.2 CHAPTER 2 OVERVIEW AND METHODS

The opening research chapter of the dissertation, “Cycling and transitions theory: A conceptual framework for identifying and promoting cycling innovations that support sustainability goals,” addresses the following sub-question:
How can the sustainable mobility paradigm be combined with the theories of the multi-level perspective and strategic niche management to evaluate whether or not cycling innovations support people who cycle and advance sustainability goals in their context of implementation?

The chapter critically examines the limited way transitions theory has been applied to the role of cycling in the transition to sustainable mobility systems. Through its novel application of a critical mobility theory (the sustainable mobility paradigm) to two transition theories (the multi-level perspective and strategic niche management principles), the chapter combines existing theoretical constructs to create a framework for evaluating the relationship between cycling innovations and sustainability goals. It then applies this framework within different institutional contexts to demonstrate how the relationship between a cycling innovation and sustainability goals is dependent on how it is implemented within a mobility regime. Specifically, this chapter categorizes cycling innovations based on whether their primary goal is to advance the system of cycling or improve the system of automobility. The chapter shows how some cycling innovations are not designed to encourage people to cycle, but rather to manage existing cyclists so that they do not interfere with the efficient operation of automobility.

3.2.1 Chapter 2 Methods

The opening research chapter, Cycling and Transitions Theories: A Conceptual Framework to Assess the Relationship between Cycling Innovations and Sustainability Goals, relies on an integrative literature review (Snyder, 2019; Whittemore & Knafl, 2005) directed towards how cycling innovations have been analyzed with the transitions theories of the MLP and SNM. Because the article addresses the limitations of one influential application of the MLP to cycling, it begins with a review of all the articles that cited this paper in reference to cycling transitions. Each referring paper was reviewed in order to determine if it expanded on the analysis presented in the source material. No paper had. One implication of this is that unresolved issues with the original application of the theory have not been resolved in later publications, either by the author or those citing the author. One of these key issues involved the sustainable mobility paradigm being left out of the analysis because of reasoning that was relevant to driving but not to cycling. Because other scholars have not addressed the issue, applying the paradigm to cycling became the basis for the chapter’s framework.

The framework was developed by combining the sustainability criteria of the SMP with the process perspective of transitions theories. The combination generates three distinct outcomes for the evaluation of an innovation. Three cases of innovative roundabouts illustrate these outcomes. The roundabout was chosen as the focus for application of the framework because its possible design configurations are sufficiently complex and varied to represent all the possible outcomes. The widespread use of roundabouts allows for a sampling across different geographic contexts. The specific cases chosen needed to meet several different conditions: they each had to represent a different outcome; two had to be from the same country and one had to be from a different country in order to show variation within and between countries; and they each had to have a sufficient number of sources about their
development and implementation in order to perform the analysis. The three examples used were selected through consultation with experts familiar with cycling developments in two distinct geographic contexts. The Netherlands examples came out of discussions with the Sustainable Urban Mobilities group at the University of Eindhoven. The example from the United States was chosen from a number of suggestions from transportation planners working in the city of San Francisco. After selecting examples to match the possible outcomes, the theoretical analysis was then illustrated based on the framework presented earlier in the chapter.

The integrative literature review process that identified the research gap for this chapter has both strengths and limitations. One of its greatest strengths is that it can demonstrate how much a topic has been referenced superficially without having been covered in detail. Beginning with an integrative literature review creates the justification for dedicating an entire chapter to a subject that previously had only been addressed by a single paragraph: the application of the MLP to cycling innovations. Dedicating a full chapter to the topic allows for an actual debate. The detailed theoretical analysis encourages other scholars to expand on the framework, disagree with particular elements, or develop something entirely new based on the same research gap. An integrative literature review is, however, by definition limited, as it is directed towards uncovering specific elements within a broader body of scholarship and is not as comprehensive as a systematic literature review (Whittemore & Knafl, 2005).

3.3 Chapter 3 Overview and Methods
The third chapter, “Mobility protests in the Netherlands of the 1970s: Activism, innovation, and transitions,” addresses the following sub-question:

In mature cycling countries, how can the strategic niche management principle of protective space be used to understand the role of historical social movements in the implementation of innovations that successfully challenge automobility?

It answers this question through an examination of the geographic, historical, and institutional contexts in which social movements, working with government actors, helped stop a rapid decline in cycling rates between the 1950s and the 1970s in the Netherlands. The chapter shows how social movements were successfully able to create a protective space that supported cycling innovations that helped reverse the negative effects of rapid motorization. The chapter demonstrates the different ways that social movements influenced and collaborated with government actors. It shows how the work of these social movements, led by people who cycled who were concerned about the effects of automobility on their cities and neighborhoods, resulted in the implementation of three specific innovations: the woonerf, the bottleneck memorandum, and the car-restricted city center. Each of these three innovations supported the maintenance of high cycling rates in the Netherlands by limiting car speeds and car access, restoring safe spaces in which to cycle.
3.3.1 Chapter 3 Methods
To assess the role of social movements in cycling innovations, the third chapter relies on a semi-structured interview methodology (Jamshed, 2014; Rosenberg, 2006) to examine the development of cycling innovations in the Netherlands. The chapter draws from ten semi-structured interviews with key actors in the Dutch mobility protests of the 1970s in which the subjects reflected on their past experiences and shared their perspectives on the outcomes of their actions.

The interview subjects were selected from a list based on a stakeholder analysis. The list was developed by drawing names from relevant scholarship (Duizer, 2005; Valenta, 2013; and Berkers, Botma, and Oldenziel, 2018), using names from the Cyclists’ Union Department Archives, and recommendations from the interview subjects themselves. Subjects were selected for interviews based on two criteria: (1) they had been active in the period considered and (2) they had a minimum of ten years of experience in mobility activism or policies in the Netherlands. A gender balance among subjects was sought in ensure that the article reflected the insights of the many women who led and participated in the developments covered by the chapter. In the final stakeholder analysis, however, most subjects were men (80%) and only one of the women on the stakeholder list agreed to an interview. The other women either did not agree to be interviewed for personal reasons (they felt they could no longer accurately recall the events we wish to discuss) or could not be found (contact information was unavailable or outdated).

The chapter also draws on scholarship, policy documents, and archival material that provide evidence of the relationship between cycling activism and 1970s Dutch cycling innovations. One of the co-authors, Henk-Jan Dekker, was working on a dissertation on Dutch cycling history while contributing to this chapter and had developed an extensive archive of source material. When an interview subject would mention a particular action, event, or development, this historical source material was cross-referenced to provide both confirmation and context for the statements by the interview subjects.

The interviews were recorded with detailed notes being taking during the interview. These notes included time indicators every five minutes. These notes were then coded to indicate the time period and subject that the speaker was discussing. The notes were then arranged by time period and subject and the most relevant sections were transcribed directly from the interview recordings. These transcriptions then formed the outline for the argument of the article.

Interviewing people directly involved with the protests movements of the 1970s provided access to information not available in published sources. Interviewing the subjects in their homes and offices also meant gaining access to supporting materials (reports, calls to action, photos, and government documents) that would likely have been impossible to locate without direct contact with the people who produced them. Speaking directly with the people involved also allowed hearing about the specific periods and subjects that were relevant for our research that had not been covered by other sources.
The interview methodology also has limitations. Around 50 years has passed between the events and the time of our research for the article. This presented a series of issues. The first is the likelihood that people may not remember or remember events incorrectly after that length of time. The second is that the people who could be located were largely those who had continued to work in the mobility sector. Because of their continued involvement in discussions around the topics covered in the article, their statements may have been unintentionally influenced by their current perspective in ways that would be difficult to determine. This limitation was addressed by verifying as many claims as possible through archival material.

The present-day male domination of the mobility profession also meant that nearly all our interview subjects were men. Women involved with care work played a prominent role in the street protests, a prominence that was not reflected in the overall gender balance of the interview subjects. Fortunately, the one woman interviewed, who had been a young parent at the time of the events described, held a prominent leadership position in the protest movements and had detailed knowledge of the participants and their motivations.

3.4 CHAPTER 4 OVERVIEW AND METHODS

Chapter four, “The challenge of the bicycle street: Applying collaborative governance processes while protecting user centered innovations,” answers the following sub-question:

In mature cycling countries, how can the strategic niche management principle of protective space be used as a means of analyzing how collaborative governance processes can compromise innovations intended to challenge automobility?

This chapter contrasts with the previous one, exploring the influence of automobility on cycling innovations and showing how innovations intended to promote a transition to sustainable transportation can be repurposed to advance the system of automobility. It does this through a detailed history of the bicycle street, an innovative street design in which people who cycle are given priority over cars, across three countries: Germany, Belgium, and the Netherlands. This chapter critically examines how the rules and processes that accompanied the implementation in each country created different ways in which the bicycle street could be implemented and different purposes that it could serve. Specifically, the article demonstrates that when the intent is to use the innovation to resolve spatial constraints, the goal of reaching consensus between different stakeholders can result in the user practices necessary to make the innovation a success not being sufficiently protected. The cases used in the article demonstrate how collaborative governance processes can lead to innovations being implemented in ways that fail to provide the protective space necessary to support the very group that they are intended to benefit. By demonstrating the unintended consequences of focusing on stakeholder consensus in an innovation project without giving primary consideration to the needs of the users of the innovation, the article demonstrates the need for more research on the connection between citizens in collaborative governance and users in innovation development. The innovation may develop sufficient support for implementation
but may not be sufficiently attuned to user practices to meet the needs of its intended user group, creating an obstacle to future upscaling. The chapter concludes with a discussion of how a particular set of enforceable guidelines could resolve this issue, preventing bicycle streets from being implemented in places where other options would better serve people who cycle.

3.4.1 Chapter 4 Methods
The chapter uses a case study methodology (Johansson, 2007; Meyer, 2016; Yin, 2012) to answer its sub-question. It examines the history of a single cycling innovation, the bicycle street, including an analysis of its development and implementation in different geographic contexts and a detailed case of a single instance of implementation in the Netherlands.

The chapter begins with a review of the existing literature on bicycle streets. This literature was divided into sources that described the operational dynamics of bicycle streets and literature that covered the intent and development of bicycle streets. This second group of literature revealed that the bicycle street has been implemented in three different countries in three distinct manners. This implementation history was synthesized to establish the relationship between the innovation and different user groups in Germany, Belgium, and the Netherlands, focusing on its original intent in each country and the regulations each country developed to protect the practices of cyclists.

The chapter then uses a case study from Eindhoven, the Netherlands to demonstrate how the bicycle street in the Netherlands can function other than intended. The case was chosen because of how its implementation in practice reflected the theoretical challenge at the core of the research question: the challenge of achieving consensus among diverse stakeholders while maintaining necessary protections for the users of an innovation.

The intent and implementation regulations of bicycle streets in Belgium and Germany was based on government documents, consultant reports, and newspaper articles. The case study of the Eindhoven bicycle street was developed through reports from the firms hired to manage the project, detailed meeting notes from participatory groups, and newspaper accounts of the project. The interpretation of these materials was supported through interviews with people with direct knowledge of the project and its history: the project leader of the redevelopment and a member of the Eindhoven Cyclists' Union who served on the participatory committees. The former national head of the Netherlands bicycle coalition who, during his time as a city alderman, was instrumental in implementing the first bicycle street in the Netherlands, was also an invaluable source for understanding the complex politics of bicycle street implementation. Because the interviews were used as background for in the interpretation of publicly available sources, most interviews were not directly cited in the chapter.

The greatest strength of the case study as a methodology for this section of the dissertation is that it provided sufficient evidence to demonstrate how a collaborative governance process around the implementation of a bicycle street with no legally enforceable guidelines could result in the innovation being used to advance the interests of those driving rather than those
cycling. The original planning documentation, community meeting notes, interviews, and newspaper reports all provided clear evidentiary support for the central claim of the article that it is possible to build a bicycle street that does not serve cyclists.

The case study approach also comes with limitations. While the article demonstrates the existence of an issue in need to resolution, it does not detail the extent of the problem, a clear limitation of a single case study. The article provides a list of the conditions that created a negative outcome, but it does not allow for an understanding of how often these conditions arise in other bicycle street implementations. The chapter, therefore, identifies a problem and proposes possible solutions. Further research is needed to understand the extent of the problem and the viability of the proposed solutions in other contexts.

3.5 CHAPTER 5 OVERVIEW AND METHODS

The fifth chapter, “Towards a Maintenance-Based Approach to Mode Shift: Comparing two cases of Dutch cycling policy using social practice theory,” addresses the following sub-question:

How can social practice theory be used to demonstrate the potential benefits of implementing innovations directed towards people who cycle?

This chapter looks at the implications that investing in the maintenance of sustainable practices could have for achieving sustainable transportation goals. It articulates a new approach to achieving mode shift, providing a broader understanding of the policy options available. This final chapter argues that the maintenance of sustainable transportation practices represents an approach missing from the policy toolkit that could complement and support current investments. It uses two Dutch national cycling policies as case studies to illustrate the argument, relating the policies to social practice theory to show how they reflect two different approaches to mode shift, one based on maintenance and the other on change. It concludes with a discussion of the potential implications and applications of this approach.

3.5.1 Chapter 5 Methods

The chapter uses the method of comparative policy analysis (Cyr & deLeon, 1975; Engeli & Rothmayr Allison, 2014) to analyze two Dutch cycling policies from different periods through the lens of social practice theory (SPT). It compares them to illustrate an approach to mode shift that is supported by existing SPT concepts but has not received attention in the literature that applies SPT to the transition to sustainable mobility systems. The chapter compares the Bicycle Less Congestion (2006-2009) to the Bicycle Master Plan (1991-1997) through an analysis based on government documents, consultant reports, and contemporaneous statements from project supporters and detractors. Most of these documents are in the Dutch language.

For the Bicycle Master Plan, this includes three comprehensive reports produced by the Ministry of Transport, Public Works, and Water Management: one states the policy of the
Bicycle Master, the second evaluates the program, and the third documents what had been accomplished after its conclusion.

The analysis of With the Bicycle Less Congestion is based on a government commissioned study conducted by a transportation consulting company that sought to predict the effects of the program, as well as supporting material from project partners that detailed goals, budgets, and implementation plans. The policies were also evaluated by collecting and reviewing critiques and commentaries on the projects that have been published in Dutch language journals.

A comparative policy analysis approach comes with both strengths and weaknesses. In this instance, its greatest strength was that it allowed for a demonstration of the clear differences between two sets of measures intended to achieve the same goal. Both policies analyzed in the chapter sought to shift the balance between cycling and driving, with one policy focusing on drivers and the other on cyclists. When the framework of social practice theory was applied to this dichotomy, it allowed for a clear presentation of the potential benefits and challenges of each approach. The comparative policy analysis was limited, however, by the inability to control for other variables. The policies were implemented at different times and by different agencies. Further, because of the numerous, complex, and interlinked variables involved with mode shift, the direct effects of each policy were not possible to measure. The comparative analysis could only demonstrate that multiple approaches were possible and that each came with its own set of implications.

4 STRENGTHS AND LIMITATIONS OF A QUALITATIVE APPROACH

A significant amount of cycling research is quantitative, providing insights into how people travel, predicting travel demand, and determining where safety issues are present (Lee & Sener, 2020). Qualitative cycling research complements this quantitative research by providing insights into approaches, processes, historical origins, meanings, and values. In this dissertation, a qualitative approach was useful for its ability to analyze the processes that underlie the development and implementation of cycling innovations. By interrogating the values, intentions, and assumptions behind the competing approaches of policymakers, the qualitative research presented here provides a framework for understanding the contextual elements that can play a key role in how cycling innovations support sustainability goals.

These qualitative elements include the governance processes behind innovation development; the stated goals of the innovation and its methods for achieving those goals; and the historical, geographic, and political context of implementation. Each of these elements, while challenging to quantify, are essential components for understanding the relationship between cycling innovations and sustainability goals and how that relationship changes across time and place. The greatest strength of a qualitative approach is its usefulness for analyzing each of these elements. The qualitative methods used here demonstrate the impact these contextual elements can have on sustainability goals.
A qualitative approach also has limitations, including the absence of meaningful measures to determine the degree of those impacts. These impacts could be measured using data collected through a quantitative approach. Cycling innovations that manage cyclists to support automobility would logically result in an increase in car trips; cycling innovations that limit automobility and serve the needs to cyclists would logically create a mode shift in favor of cycling. These are measurable outcomes, although their measurement is often complicated by a lack of access to the necessary data and the challenges of controlling for many variables. While quantitative methods were outside of the scope and budget of this research, collecting and analyzing quantitative data could support the conclusions made here through qualitative methods, strengthening the arguments made in the dissertation by providing empirical evidence for the potential effects on sustainability described in the chapters. The conclusion of the dissertation describes both the results obtained from the qualitative methods used here and how quantitative methods could play a role in potential future research projects.
## 5 Key Chapter Information

<table>
<thead>
<tr>
<th>Chapter 2: Cycling and transitions theories: A conceptual framework to assess the relationship between cycling innovations and sustainability goals</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sub-question</strong></td>
</tr>
<tr>
<td><strong>Methodology</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chapter 3: Mobility protests in the Netherlands of the 1970s: Activism, innovation, and transitions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sub-question</strong></td>
</tr>
<tr>
<td><strong>Methodology</strong></td>
</tr>
</tbody>
</table>
### Chapter 4: The challenge of the bicycle street: Applying collaborative governance processes while protecting user centered innovations

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub-question</td>
<td>In mature cycling countries, how can the strategic niche management principle of protective space be used as a means of analyzing how collaborative governance processes can compromise innovations intended to challenge automobility?</td>
</tr>
<tr>
<td>Methodology</td>
<td>Case study</td>
</tr>
</tbody>
</table>

### Chapter 5: Towards a maintenance-based approach to mode shift: Comparing two cases of Dutch cycling policy using social practice theory

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub-question</td>
<td>How can social practice theory be used to demonstrate the potential benefits of implementing innovations directed towards people who cycle?</td>
</tr>
<tr>
<td>Methodology</td>
<td>Comparative policy analysis</td>
</tr>
</tbody>
</table>
Chapter 2: Cycling and Transitions Theories: A Conceptual Framework to Assess the Relationship Between Cycling Innovations and Sustainability Goals

1 INTRODUCTION

In transportation governance, an increasing amount of attention is being paid to the promotion of cycling as a key component in the transition to sustainable transportation systems (Bruno & Nikolaeva, 2020; Gössling, 2013; Gössling & Choi, 2015; Jensen et al., 2017; Larsen, 2017; McAndrews et al., 2018; Olmos et al., 2020). Articles that focus on the promotion of cycling often only refer to a transition to sustainable transportation systems, however, without directly engaging with sustainability transitions theories. They tend to list a contribution to sustainable transportation as part of a longer list cycling benefits that includes improving health outcomes, increasing mobility, lowering injury rates, alleviating congestion, and reducing delays through overall system efficiency improvements (Gössling, 2013; Handy et al., 2014; Liu et al., 2019; Pucher et al., 2010). When examining cycling innovations, whether or not a cycling innovation improves the health, mobility, or safety of people who cycle is a different question, however, from whether and to what degree the innovation contributes to the transition to sustainable transportation systems. Some cycling innovations do not promote cycling but rather manage how and where people can cycle in order to reduce travel times for people driving. For example, special bicycle bridges or tunnels at intersections can reduce the signal times for people driving while creating extra effort for people cycling. For this reason, not all innovations directed towards people cycling may contribute to sustainable transportation transition processes, as they may discouraging the use of sustainable modes and encouraging the use of unsustainable ones.

Cycling is considered one of the most sustainable forms of transportation in social, economic, and ecological terms as it “gives people the possibility of travelling in an affordable, healthy, safe, resource-efficient and environmentally friendly way” (Pospischil & Mailer, 2014, p. 81). As noted by Cresswell (2010b, p. 21), however, “mobilities are both productive of social relations [that involve the production and distribution of power] and produced by them.” Both in mobility regimes where cycling is well-established and in those where it is less developed, the system of cycling must compete for money, space, and political attention with the system of automobility (Petzer et al., 2021). Literature on vélocimobility - a term that

includes not only the practice of cycling but all of the surrounding supportive systems that make cycling possible as a form of transport (Behrendt, 2016; Horton et al., 2007) – has explored the contested nature of cycling within the transportation system (Cox, 2019; Freudendal-Pedersen, 2015a; Koglin & Mukhtar-Landgren, 2021). Within this critical véloomobilities scholarship, Koglin & Rye (2014) have extended Cresswell’s ideas on the politics of mobility (Cresswell, 2010b, 2010a, 2012a) specifically to the concept of véloomobility, arguing that bicycle planning could be advanced through the application of mobility theory.

Similarly, this article argues that a cycling supported transition to sustainable transportation systems could be better understood through by directly applying transitions theories to innovations related to véloomobility. This article, therefore, applies the sustainable mobility paradigm to the transition frameworks of the multi-level perspective and strategic niche management in order to analyze innovations related to véloomobility. It argues that innovations designed to increase the efficiency of the system of automobility cannot be considered effective tools for achieving a transition to sustainable mobility and examines how innovations designed to challenge automobility can be adapted to succeed in the area in which they are implemented.

The article begins with a theory section that provides a brief overview of the multi-level perspective and strategic niche management principles and how they have been applied to cycling. It then describes the principles of the sustainable mobility paradigm and how its application to transitions theories can be useful for understanding the role of cycling innovations in transitions. The methodology section develops this application of the SMP to transitions theories into a process for assessing the relationship between cycling innovations to sustainability goals.

The analysis section then demonstrates this process through an evaluation of three related cycling innovations implemented in different mobility regimes. Examining three instances of innovative roundabout designs, each in a differently configured mobility regime, the analysis section shows how one general type of cycling infrastructure can result in multiple possible outcomes for sustainability transition goals. The discussion section describes how the process can be applied beyond the examples provided in the analysis section to advance a transition to sustainable transportation systems where cycling plays a key role.

2 THEORETICAL FRAMEWORKS TO ASSESS THE RELATIONSHIP BETWEEN CYCLING INNOVATIONS AND SUSTAINABILITY TRANSITIONS

The following three sub-sections provide a brief overview of the multi-level perspective, the sustainable mobility paradigm, and strategic niche management principles as they relate to cycling innovations. It critically assesses the mode-based approach used in the current application of the MLP to transportation and argues that an approach that considers place
specific mobility regimes would allow for improved analysis. It then discusses the role of the 
SNM and SNM in this approach (see Figure 1).

<table>
<thead>
<tr>
<th>Framework</th>
<th>Abr.</th>
<th>Purpose</th>
<th>Relevance for understanding cycling innovations</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Multi-level Perspective</td>
<td>MLP</td>
<td>To analyze processes behind the success or failures of innovation implementation &amp; upscaling</td>
<td>Provides a model for how cycling innovations might become widely adopted irrespective of their sustainability goals</td>
</tr>
<tr>
<td>Strategic Niche Management</td>
<td>SNM</td>
<td>To analyze how innovations challenging existing system can be implemented and upcaled</td>
<td>Provides a model for the modification of cycling innovations within mobility regimes</td>
</tr>
<tr>
<td>The Sustainable Mobility Paradigm</td>
<td>SMP</td>
<td>To define key elements of sustainable mobility and identify &amp; promote innovations that advance it</td>
<td>Provides a means for assessing whether cycling innovations advance sustainability goals</td>
</tr>
</tbody>
</table>

Figure 1: Overview of the theoretical frameworks used in the article.

2.1 THE MULTI-LEVEL PERSPECTIVE’S MODEL OF TRANSITION PROCESSES

The need to transition to sustainable energy, transport, housing, and food production has received an increasing amount of attention in academic literature (Campos & Marín-González, 2020; Köhler et al., 2019; Sovacool & Geels, 2016; Whitmarsh, 2012). The multi-level perspective (MLP) has become a widely used framework for conceptualizing these potential
transitions processes (Fraedrich et al., 2015; Geels, 2005; Kenger & Schot, 2016; Köhler et al., 2019; Voß et al., 2009). The MLP considers innovative technologies and ideas in the context of socio-technical regimes, the institutional structures of large systems, and how these regimes might incorporate innovations (Köhler et al., 2019).

According to the MLP, transitions are non-linear processes that come about through the interactions within and between three levels: niches, socio-technical regimes, and the broader socio-technical landscape (Geels, 2012; Geels & Schot, 2007). Socio-technical regimes are defined by written and unwritten rules followed by the companies, government actors, end-users, and other stakeholders in the domain of the innovation. The MLP classifies innovations as either incremental or radical niche innovations, depending on whether they conform to established systems or present a challenge to those systems (Köhler et al., 2019). Niches, which both regime actors and non-regime actors can initiate, are the source of innovations that challenge the existing regime. These radical niche innovations depart from existing practices and can potentially originate from groups like research and development projects, start-ups, or government subsidized experimental programs. The socio-technical landscape is the broader physical and social context beyond the control of individual actors (Geels, 2012; Frank W. Geels & Schot, 2007). Rather than focusing exclusively on technology or economics, the MLP takes an actor-based approach and looks at the interactions between groups within and across the different levels (Kemp et al., 2012).

2.2 APPLYING THE MLP TO CYCLING INNOVATIONS

Previous scholars have written about the application of the MLP to cycling, but they have addressed the subject only very briefly, describing cycling with language and concepts that are not particularly useful when cycling innovations are the primary focus of analysis. The section that follows includes a brief overview of one of the most influential applications of the MLP to cycling and explains why both its mode-based framework and one of the key terms that it uses within this framework create limitations when applying the MLP to cycling. It then discusses how a different approach to how modes are considered when applying the MLP to transportation innovations could result in an improved understanding of the role of different modes in sustainability transitions.

Geels’ (2012) “A socio-technical analysis of low-carbon transitions: introducing the multi-level perspective into transport studies” is one of the most influential and widely cited articles for how to use the MLP to understand sustainable transportation processes. Even though the article only briefly addresses cycling in combination with public transit, it has made a significant contribution to how cycling is discussed within transitions literature with the designation of a word to encompass the regimes of both cycling and transit: subaltern. The following passage provides the article’s complete explanation for the use of the term subaltern to describe the regimes of public transportation and cycling:

In the transport domain there is not just one regime (auto-mobility), but also other regimes (e.g. train, tram, bus, cycling). These transport modes have been around for many decades,
are carried by specific communities of actors that have developed institutionalized practices, beliefs, capabilities etc. It makes no sense to call these transport modes ‘niches’ in the sense of being radically new and precarious innovations. But these transport modes capture only a small percentage of total mobility (in terms of passenger kilometers), and in that sense occupy small market niches. These transport modes can be called subaltern regimes in contrast to the dominant auto-mobility regime (Geels, 2012, p. 473).

The next paragraph in Geels’ article discusses the regime concept in general with no further description of or attention to the subaltern concept and how it relates to either cycling or transit. This reflects a more general lack of attention in transitions literature to the role of cycling as a socio-technical system and its relevance to the transition to sustainable transportation systems. In a book that applies a socio-technical analysis to sustainable transport, leading transition scholars acknowledge this limited consideration for cycling but justified this lack of attention by arguing that cycling has “limited interactions with automobility,” the primary focus for most academics writing about transitions in the area of transportation (Kemp et al., 2012, p. xiii)

Even though very little explanation is given for the use of the term subaltern, scholars have widely adopted the term, citing Geels et al. (2012) without providing any further elaboration themselves (Bruno, 2020; Cass, Schwanen, & Shove, 2018; Geels, 2018; Marletto, 2014; Oldenziel, 2017; Schwanen, 2015). Canitez (2019) briefly addresses the subaltern regime concept, but only to argue that it should not be applied to places with extremely low cycling rates where cycling would be better conceptualized as a niche. When applying the MLP to cycling in different contexts, as this article does, the use of the term subaltern requires further consideration, as two specific issues related to its justification and implied meaning present problems for adopting it as a useful label when describing cycling innovations and transitions.

The first issue is that the application of subaltern relies on a single measure, number of passenger kilometers globally, to imply something very specific and expansive about the status, power, and influence of these modes across different mobility regimes. While bicycle trips may make up a small number of passenger kilometers globally, the relevant metric when analyzing a cycling innovation would be the number of trips taken by bicycle locally. As the analysis by Oldenziel et al. (2016) shows, that number can vary substantially based on the urban landscape and cycling distances, alternatives to cycling, how cycling is approached in traffic policy, the existence of social movements to support cycling, and the cultural status of cycling. In places that are favorable to cycling in each of these categories, such as Copenhagen and Amsterdam, the number of cycling trips may be greater than the number of car trips. The term subaltern, however, coming from the Latin sub- (below) and alternum (every), implies not just a subordinate position but the lowest position. For this reason, the Italian Marxist Antonio Gramsci famously introduced the term to describe groups completely outside of power (El Habib Louai, 2012; Gramsci, 1971). The term was later adopted in Spivak’s widely cited “Can the subaltern speak?” (1988) for discussions in post-colonial studies on the power structures surrounding groups denied influence over their own governance. Since then, other scholars, including in transition studies, have borrowed the term in multiple ways, not in reference to
subaltern regimes as described by Geels (2012), but in reference to the mobility of groups excluded from traditional power structures (Buliung et al., 2015; Cresswell, 2012b; G. Mom et al., 2011; G. P. A. Mom, 2015; Spinney, 2016). For example, in “Struggles in European energy politics: A gramscian perspective on power in energy transitions,” the author argues Gramsci’s ideas should be integrated into transitions theory, including adopting the concept of subjugated subaltern classes (Haas, 2019). Citing Geels (2012) application of subaltern to describe cycling and transit regimes therefore implies an analysis of power relations that does not appear in the original text. Velomobilities literature has critically examined the effectiveness of cycling policies that make sustainability claims, including how these polices reflect power dynamics between velo- and automobility (Bonham & Cox, 2010; Cox, 2005; Henderson & Gulsrud, 2019; Koglin & Mukhtar-Landgren, 2021), but the subaltern regime concept as used by Geels (2012) does not reference any mobilities literature, making it unclear if the term is intended to claim anything, either directly or by implication, about power dynamics between vélo and automobility in transitions processes.

Even if subaltern might be a useful concept for describing the power dynamics between advocates for cycling and proponents of other modes in some contexts, the concept is not optimal for analyzing cycling innovations within a transitions framework. The subaltern concept as defined by Geels (2012) is part of an analysis separated by mode, with only the modes with the highest modal share globally worthy of consideration. This siloing of modes fails to capture the ways different travel modes are integrated and interact with each other, allowing a mode with a low share of ridership to still have a significant impact on the transportation system as a whole.

As Schwanen (2015) notes, different modes of travel are often symbiotic and synergistic. Even if one mode of transportation has more use than another, the two modes may be heavily intertwined, with a large overlap in the actors and processes involved with the regimes of automobility, transit, and cycling. This can include the financing each mode draws on, the transportation planners responsible for designing and implementing the transportation networks, and the many people who make multi-modal trips, whether that be driving to a train station or using a bike share system after getting off a bus.

Applying the term generally to all forms of transit and cycling implies that transit and cycling are always separate and lesser—that they are subaltern. This is a poor assumption to use as a starting point for analysis because it will likely result in an underestimation of the role of these modes within mobility regimes. Even when they have a lower mode share, transit and cycling still support and expand the transportation system, allowing people to both substitute one mode for another and adding possibilities for multi-modal trips. In situations where transit and cycling are in direct competition for space and resources with cars (Petzer et al., 2021), these modes still help alleviate the negative externalities created by cars, which is often part of the justification for providing transit and cycling with increased space and resources (Brand et al., 2014; Fishman, 2016; Ogilvie et al., 2011; Pucher et al., 2010).

This article argues for examining a particular mode within the institutional context of specific mobility regime rather than making any assumptions about the mode across all mobility
regimes. This avoids the a priori assumption of extremely unequal power dynamics contained in the term subaltern and instead allows for a focus on the relational aspect between public transit, cycling, walking, and automobility. For those involved with alternative and active modes in both research and practice, this places the emphasis on the role they have in the transportation system rather than on an assumed relative lack of significance. As the next section sub-section describes, this is of particular importance when discussing cycling, as there may be significant differences in the configuration of regimes between institutional contexts.

2.2.1 Variances in vélocimobility between mobility regimes

In applying MLP to transport, Geels (2012, p. 475) notes, “Regimes such as bus, light rail and cycling also have strong local dimensions… this spatial dimension of transitions needs to be further elaborated in future work.” This is particularly true when considering cycling as a socio-technical system where substantial differences in cycling rates have significant implications for the processes and outcomes involved with efforts to increase the cycling mode share (Harms et al., 2014; Pucher & Buehler, 2008a; Silva et al., 2019). Considering cycling as a socio-technical system involves examining the entire “configuration of technologies, services, infrastructures, regulations, and actors,” (Kenger & Schot, 2016, p. 599).

Canitez (2019) has defined the socio-technical system of cycling as consisting of user practices, industry, infrastructure, technology, regulations and policies, culture and symbolic meanings, and knowledge, as well as the built and natural environment. Because this article examines the relationship between cycling innovations and people who already cycle, it considers the socio-technical regime of cycling in places with an established institutional context around cycling as a form of transportation. For the purposes of this article, this would mean that, at a minimum, the following elements are present: cycling is given attention by transportation planners and is a part of the long-term transportation plan; a sufficient number of people cycle to register in mode share statistics; and that some form of a cycling network, whether shared or separated, exists. The variation in cycling rates between places that fit these basic criteria can be significant. In reviewing places where cycling has received substantial institutional support over the past 20 years, Pucher et. al. (2010) consider cities where the cycling mode share varies from 1.2% (London, UK) to 40% (Groningen, the Netherlands). While they note the many similarities in the approaches of each of the cities examined, their detailed breakdown of the cycling rates, safety levels, infrastructure, and programs in each city shows how differently cycling can be constituted in different mobility regimes. This reflects the assertion by Prince (2017) that mobility policy may have global connections but a thorough understanding local dynamics is necessary to understand what specifically is implemented and why. The examples provided in this article give specific attention to these local dynamics and how they vary between mobility regimes.

In considering how vélocimobility operates within a given mobility regime, the configuration of the automobility regime is also relevant. Jeekel’s (2011) study of car dependency in the Netherlands shows that even the places with the highest cycling rates still have strong automobility regimes. This reflects Hansen and Coenen’s (2015) assertion that a single place can be reflective of multiple norms and values. Specifically, a mobility regime can use cycling
innovations to advance both vélocity and automobility. For example, Oldenziel and Albert de la Bruhèze’s (2011) note this duality in their history of the separated bicycle lane in Europe. The authors note that the separated bike lanes that began to appear in various European cities from the late 1920s were opposed by cycling groups because they were seen as a means to restrict access to the use of the main road but advocated for by planners and policymakers because they would make streets more efficient for car traffic. The separated bicycle lane was thus seen as a step towards removing cyclists in order to create car-only travel lanes. Cyclist groups pushed back, demanding their right to the street as car ownership increased and then, from the 1970s, reclaiming the separated bicycle lane as a means for gaining safe access to streets that had been designed exclusively for car access. As Oldenziel and Albert de la Bruhèze (2011) note, entrusting a cycling innovation to advance sustainable mobility goals without interrogating the context in which it is being implemented can result in long term investments that do not support sustainability goals.

The central question, therefore, is not which mode the innovation primarily focuses on, but whether or not the innovation is advancing sustainability goals. The sustainable mobility paradigm provides a means for answering this question, as the next section explains.

2.3 APPLYING THE SUSTAINABLE MOBILITY PARADIGM TO CYCLING INNOVATIONS

As described by Banister (2008), the sustainable mobility paradigm recognizes that moving towards sustainable transportation requires a different approach than traditional car centered transport planning and engineering. The paradigm does not simply advocate shifting resources from unsustainable to sustainable modes. Rather, the paradigm addresses the logical outcomes of following two different and opposing approaches. What Bannister refers to as the conventional approach focuses on the car on a large scale, forecasting traffic and minimizing travel times. The sustainable mobility approach, on the other hand, focuses on the local scale: slowing movement down, integrating people and traffic, and giving priority to pedestrians and cyclists over motorized traffic. When applied to cycling innovations, it can provide a means for identifying which cycling innovations can provide the strongest support to a transition to sustainable mobility.

While it does not directly employ concepts from transitions theories such as the multi-level perspective and strategic niche management, transition scholars have recognized the value of the sustainable mobility paradigm. They have, however, not used the theory systematically for understanding sustainable mobilities transitions. For example, in their introduction to an anthology on sustainability transitions and automobility, leading transitions scholars refer to the sustainable mobility paradigm as “the best attempt to define sustainable mobility” (Kemp et al., 2012, p. 10). Remarkably, they do so without using SMP as a framework of analysis, arguing that sustainability is generally a secondary concern for transport agencies when considering which policies to implement (Kemp et al., 2012). It is precisely in this manner, however, that cycling as a mode of transportation differs from automobility, as transport agencies often do implement cycling policies, programs, and innovations explicitly for the
advancement of sustainability goals (Karanikola et al., 2018; Pospischil & Mailer, 2014; Pucher & Buehler, 2017) and people who cycle often see their choice to do so as making a contribution to sustainability goals (Blickstein & Hanson, 2001; Dalpian et al., 2015; Horton, 2006).

Kemp et al. (2012) also state as one of their interests “whether the developments and innovations are within the regime of automobility or an element of alternative mobility” (Kemp et al., 2012, p. 10). This article argues for the application of the sustainable mobility paradigm because of its direct relevance to answering that question. By foregrounding the goals behind the implementation of an innovation, the sustainable mobility paradigm can be used to look beyond what mode an innovation is associated with and instead look at the relationship between the innovation and the development of sustainable mobility systems.

This paper argues that the implementation of cycling innovations sometimes—but not always—challenges the automobile regime. As Geels notes, “governments tend to facilitate car mobility, because the car is culturally accepted and embedded in people’s lives.” (Geels, 2012, p. 480) This means that cycling innovations, including those that make sustainability claims, should not be accepted uncritically as tools to bring about a mode shift. Assuming that an investment directed at cycling will automatically lead to a decrease in driving ignores how automobility has adapted and has continued to be promoted throughout the period of advocacy for more sustainable modes of transportation (Schwanen, 2016; Wells & Xenias, 2015). A cycling innovation that aligns with conventional car-oriented planning may still be promoted as a tool for advancing sustainability goals. One possible reason for this could be existence of transport taboos, barriers to implementing sustainable transportation policies that government actors will not address because of the perceived political risk involved (Gössling & Cohen, 2014). Within the transport taboo framework, policymakers and elected officials avoid discussing restrictions on automobility, even when such measures are understood to be effective for advancing sustainability goals and have majority public support, in part because the successful lobbying efforts from groups invested in automobility. Cycling policies that do not interfere with such automobility taboos can make claims about advancing sustainability goals without risking a challenge from automobility regime actors.

Strategic niche management (SNM) provides a framework for understanding cycling innovations that do challenge the automobility regime and their potential for implementation and upscaling. As the next subsection describes, SNM also addresses the types of challenges these path-breaking innovations may face within mobility regimes where cycling rates are low or cycling does not have strong institutional support.

2.4 STRATEGIC NICHE MANAGEMENT, PROTECTIVE SPACES, AND THE ADAPTATION OF SUSTAINABILITY PROMOTING CYCLING INNOVATIONS

Strategic niche management scholarship provides a framework for understanding the conditions under which cycling innovations that support sustainability goals can be implemented and how they might change in response to the regime of automobility. It asserts
that path-breaking innovations often need time to develop in protective spaces in order to survive initial struggles in adapting to the pressures created by incumbent socio-technical regimes (Smith & Raven, 2012). Strategic niche management theory describes two ways of empowering path-breaking innovations so that they can succeed outside of these protective spaces: fit and conform empowerment, in which the innovation adapts to existing conditions, and stretch and transform empowerment, in which the innovation brings about transformative changes to the its implementation environment (Smith & Raven, 2012). For a cycling innovation, succeeding outside of a protective space would involve managing pressures created by the system of automobility if the cycling innovation require elements such as reducing car lane capacity, removing car parking spaces, lowering motorized traffic speeds, and changing signal timing to prioritize people cycling through intersections. All of these elements not only involve interactions with automobility, but also challenge it by limiting car speeds and car access.

Promising cycling innovations that challenge the demands of automobility therefore need protective spaces in which they can be developed, implemented, and potentially accepted. The strategic niche management (SNM) approach offers a long list of methods for providing such protection (Caniëls, Romijn, Caniëls, & Romijn, 2006; Raven, 2005, 2010). This includes methods for protecting the innovation from market forces, but also strategies for implementing innovations in protective spaces where they have time to adapt to user practices and gain public acceptance: a form of protection often needed for cycling innovations.

While places with high cycling rates also have a contested and complicated relationship between vélocity and automobility (Cox & Koglin, 2020; Freudendal-Pedersen, 2015a, 2015b; Henderson & Gulsrud, 2019), conditions within mobility regimes with a long history of cycling and established institutional actors dedicated to advancing cycling can sometimes allow for the development and implementation of cycling innovations that challenge automobility (Bruno, Dekker, & Lindenberg Lemos, 2021; Koglin, 2015; R. Oldenziel, Emanuel, Albert de la Bruhèze, & Veraart, 2016). In places where cycling is less developed within the mobility regime, direct support and protection is likely to be necessary for similar innovations to be successful. If this support and protection is absent, this could result in the infrastructure either not being implemented or substantially altered by pressures from the regime of automobility, as the promotion of cycling can bring about intense resistance from those invested in the system of automobility (Field et al., 2018; Roberts, 2020).

In places with high cycle rates where cycling has been normalized across age groups (den Hoed & Jarvis, 2021), this resistance to cycling infrastructure and to cycling innovations, may be far less present. As one scholar stated in their explanation for why the cycling culture of the Netherlands receives more attention from outside than within the country: “For most Dutch, cycling is not remarkable enough to pay a lot of attention to” (Stoffers, 2012, p. 93). Without the same levels of resistance to cycling innovations that challenge automobility, mobility regimes where cycling is well established may not need the same level of strategic niche management principles for innovations that support cycling to succeed, with incremental
innovations developing out of a mobility regime where consideration for people who cycle is well integrated (see Section 4). When mobility regimes where cycling is less developed attempt to implement similar innovations, however, they may function as radical niche innovations and are likely to require strong strategic niche management protections to succeed at advancing sustainability goals.

The subsections above outlined the MLP, the SMP, and SNM and why they are relevant to understanding the role of cycling innovations in a transition to sustainable transportation. This article shows how the SMP can be operationalized within the frameworks of the MLP and SNM to analyze the potential of cycling innovations to support sustainability goals within differently configured mobility regimes. The following methodology section explains this operationalization process.

3 METHODS AND MATERIAL

The theoretical overview of this article relied on an integrative literature review (Snyder, 2019; Whittemore & Knafl, 2005) directed towards determining how cycling innovations have been analyzed using the MLP and SNM transitions theories. Previously, the MLP had only been applied to cycling to a limited degree, receiving a brief mention in a highly influential article on the application of the MLP to transportation (Geels, 2012). As this analysis is concerned with the limitations of that influential article in relation to cycling, the analysis process began with a review of all the articles that cited this paper, checking each of them for references to cycling. The articles that did reference cycling (Canitez, 2019; Cass et al., 2018; F. W. Geels, 2018; Marletto, 2014b; Oldenziel, 2017; Schwanen, 2015) were reviewed to determine if they expanded or clarified the analysis presented in the source material. No paper did. This process established that the limited attention to cycling in the source publication had not been addressed in later publications. One of the key limitations of this original analysis involved the SMP being determined to not be relevant because of reasoning based on issues related only to automobility and not vélocimobility. Having identified this issue and having determined that it had not been addressed by other publications, the clear relevance of the SMP in the application of the MLP to cycling became the basis for the framework presented by the article.

Similarly, while the SNM has been previously applied to cycling innovations (Bruno, 2020; Hoogma et al., 2002; Isaksson & Alm, 2022), it has also not been used in combination with the SMP. This article, therefore, makes a unique contribution through its operationalization of elements of the MLP, SNM, and the SMP for the analysis of cycling innovations (see figure 2). The analysis consists of four key questions organized in a two-part structure. The first question addresses how cycling is configured as a socio-technical system within a mobility regime. The following three questions examine how a cycling innovation functions within that context. These questions assess whether the innovation advances sustainability goals, whether it challenges the existing mobility regime, and whether it needs protections or adaptations. These four questions seek to create a broad framework to analyze whether a cycling
innovation helps advance a transition to sustainable mobility and whether specific protections and adaptations are necessary to preserve the elements that support that transition.

Next, the article uses a comparative case study approach where cases are chosen by “tracing across sites and scales to understand how the phenomenon came into being, how it has been appropriated by different actors, and how it has been transformed in practice” (Bartlett & Vavrus, 2017, p. 10). In this instance, the comparative case study focuses on three instances of innovative roundabout design, each in a differently configured mobility regime. The roundabout was chosen because of its ability to be reconfigured to accommodate different types of traffic in different ways. This allows one general type of cycling infrastructure to illustrate the multiple possible outcomes for how a cycling innovation can be conceptualized. The three case studies of roundabouts were chosen because of their similarities in underlying form but significant differences in the analytical results. The locations were chosen across two countries, one with high cycling rates and the other with low cycling rates, to show different outcomes both within and between high and low cycling contexts. The background material for the case studies came from searching the local newspapers and government agency archives for each area and including the relevant articles and policy documents in the analysis. Source material also came from conducting a general internet search to locate comments on the projects from the relevant design firms and policymakers. For the cases from the Netherlands, Dutch language search terms and sources were used; Dutch language quotes have been translated into English by the author. While the three examples that follow were chosen for their contrasting outcomes, the analysis could be applied to any cycling innovation implemented within a mobility regime with an established socio-technical cycling system.
Operationalizing the MLP, SNM, and the SMP to analyze cycling innovations’ role in the transition to sustainable transportation systems

**Question 1:** How is vélomobility configured as a socio-technical system within the mobility regime where the innovation is being implemented?

**Relevance:** Understanding how a cycling innovation functions requires understanding how cycling is configured within the mobility regime.

**Criteria:** modal split; institutional support for cycling; quality of the cycling network; the role of cycling in formulating transportation sustainability goals; cycling regulations and policies, cultural and symbolic meanings of cycling; the built and natural environment.

**Question 2a:** Within the mobility regime in which it is being implemented, does the innovation reflect a conventional planning approach or a sustainable mobility approach?

**Relevance:** Cycling innovations fitting the sustainable mobility paradigm are likely to be more effective in advancing sustainability goals.

**Criteria:** People cycling prioritized over people driving; traffic calming; integration of people and traffic; management rather than demand based; local in scale

**Question 2b:** If the innovation reflects a sustainable mobility approach, is it an incremental innovation or radical niche innovation within the mobility regime?

**Relevance:** In implementation and upscaling processes, radical niche innovations may more rapidly advance sustainability goals, but they may also require more protections and adaptations than incremental innovations.

**Criteria:** Whether cycling is well established in the mobility regime where the innovation is being implemented; the degree to which the innovation challenges automobility; whether or not the innovation is a direct extension of existing cycling measures.

**Question 2c:** If radical, what strategic niche management strategies help it succeed within the specific mobility regime?

**Relevance:** Radical niche innovations may require additional protections or different configurations than incremental innovations because in low cycling contexts cycling innovations are more vulnerable to pressures automobility.

**Criteria:** the presence of protective space; differing degrees of stretch-and-transform or fit-and-conform alterations.

Figure 2: Operationalizing the MLP, SNM, and the SMP to analyze cycling innovations’ role in the transition to sustainable transportation systems
4 RESULTS

The results section provides an illustration of how the sustainable mobility paradigm can be used with MLP and SNM concepts by examining similar types of cycling innovations implemented in different mobility regimes. The analysis applies the analysis questions from Figure 2 to examples of innovative roundabouts in three different cities (see Figure 3): one in Eindhoven, a city in the south of the Netherlands with a population of a quarter of a million people that applied modernist planning principles after being heavily damaged during World War II (Oldenziel et al., 2016); one in Zwolle, a city in the east of the Netherlands with a population of 130,000 and a historic city center with buildings dating back to the 14th century (CBS, 2022; van Rossum, 2021); and San Francisco, a city on the California coast in the United States with a population of 900,000 and density of 19,000 residents per square mile, making it the second most densely populated major city in the United States after New York City (Sumida, 2021). Each city has a distinct configuration of its mobility regime (see Q1 of Figure 2), as shown through a comparison of the modal split numbers (see Figure 4). Three different innovative adaptations of a specific type of cycling infrastructure within these different mobility regimes are analyzed: a roundabout that accommodates cyclists. This section evaluates these roundabout innovations based on where they fit in the sustainable mobility paradigm, whether or not they are incremental or radical innovations (MLP), and, if radical, whether or not strategic niche management strategies have been used within the institutional context in which they were implemented. The three cases were chosen in order to demonstrate different outcomes of the evaluation process. The first case, the Hovenring in Eindhoven, shows how cycling innovations can support automobility in ways that do not advance sustainability goals. The second case, a cycling focused roundabout in Zwolle, demonstrates the role of incremental cycling innovations in advancing sustainability goals. The final case, a Dutch inspired roundabout in San Francisco, shows the role of strategic niche management principles in implementing a cycling innovation that, in the context of its mobility regime, is a radical niche innovation. Taken together, the three examples illustrate how an analysis drawing on the framework proposed in Figure 2 can be used to determine if a cycling innovation helps advance a transition to sustainable mobility and whether or not specific protections and adaptations are necessary to preserve the elements that support that transition.
Figure 3. (A) The Hovenring in Eindhoven, the Netherlands (B) A bicycle roundabout in the Zwolle, the Netherlands that limits the route options for cars (C) A Dutch influenced mini-roundabout in the Presidio National Park in San Francisco, CA [images from European Cyclists’ Federation, CC BY 2.0; Google; Presidio Trust, 2021]

Figure 4. The modal split in San Francisco (Corey, Canapary, 2019), Eindhoven (R. Oldenziel et al., 2016), and Zwolle (KiM, 2014) *other consists of taxi and private ride share company trips, which are combined with walking in the Dutch data sources because they comprise only a small number of trips.
4.1 The Eindhoven Hovenring: An Incremental Innovation in a High Cycling Context Reinforcing a Conventional Planning Approach

In June 2012, the city of Eindhoven completed the construction of an 11 million Euro raised roundabout exclusively for cyclists (Van den Bergh, 2019). The roundabout, a circular steel bridge 72 meters in diameter and suspended by cables from a 70-meter central pylon, allows people travelling by bicycle to pedal above and across the intersection without having to stop for the car traffic below (ipv Delft, n.d.). It was the world’s first suspended cycling path roundabout (Door, 2014).

The striking design of this innovation gives it the appearance of a radical innovation design to challenge automobility (see Figure 3), a presumption further reinforced by the amount of attention the innovation received from international cycling publications (Fairhurst, 2013; Mercanti, 2013; Ollinger, 2013; Stuckless, 2020). It represents, however, the conventional planning paradigm. According to one of the council members responsible for the project at the time, the Hovenring was not intended as a prestige project to demonstrate a new direction in the city’s cycling infrastructure. Rather, it had a specific and functional purpose that was used to justify the high costs: “We wanted to separate bicycle and car traffic and to do that we needed to go up in the air and into the ground. That makes it expensive” (Eindhovens Dagblad, 2021, p. 1).

The innovation was the logical outcome of innovations developed in various cities of the Netherlands over decades to separate bicycles and cars for the specific purpose of maintaining the uninterrupted flow of automobility. As noted by Dekker (2021) in his comprehensive history of cycling governance in the Netherlands, government salary controls in place until the 1960s in the Netherlands resulted in high rates of car ownership coming to the Netherlands at a much later time than in other European countries. When rapid increases in car ownership did occur in the Netherlands in the late 1960s, the prominent modernist trend of removing bicycle lanes in order to plan for a car-oriented future was no longer as popular in the Netherlands as it had been during the earlier rise of automobility in other European countries. Cycling rates were still high in the Netherlands well into the 1960s and movements focused on social activism and democratic participation resulted in demands for a place for cycling in the Dutch transportation system. Dutch cities that suffered severe damage to their centers during the second world war, however, such as Rotterdam and Eindhoven, still saw an opportunity to improve the efficiency of car travel by building arterial roads through the city. In the 1960s, Eindhoven began to separating car and bicycle traffic so that bicycles would not slow down cars even though most trips in the city at the time were by bicycle. By 1976, the city had built 155 kilometers of separated bicycle infrastructure, including a series of eight bicycle tunnels that led people underneath both the older rail infrastructure and the newly constructed arterial roads that traversed the city center (Oldenziel et al., 2016). As a result of this modernist approach to planning that focused primarily on facilitating car traffic, between the late 1940s and 2010, around the time of the construction of the Hovenring, the bicycle’s share of the modal split had dropped from 53% to 22% (see Figure 4, and Figure 2, Question 1).
While this is a higher number than many places in the world, it still lower than other Dutch cities such as Amsterdam (28%) or Utrecht (27%) (R. (Ruth) Oldenziel et al., 2016).

In the 1970s, the city of Eindhoven also adopted an innovation first used in another Dutch city: the Bear Pit, a sunken area below a busy intersection that allowed cyclists to descend underneath the intersection and climb up on the other side without stopping and without interfering with car traffic (R. (Ruth) Oldenziel et al., 2016). In conveying the design of the Hovenring to its readers, the local Eindhoven newspaper gave a short but simple description: “a kind of turned around Bear Pit” (Van den Bergh, 2019, p. 1). The structure’s incremental advance of an existing intersection design is reflective of how both the Bear Pit and the Hovenring were developed out of a conventional approach to planning that prioritizes minimizing travel times for cars.

Prior to the construction of the Hovenring, the intersection had a level roundabout for both bicycle and car traffic. For car traffic, the roundabout was an important link to the country’s main north-south highway and the city’s airport (ipv Delft, n.d.) (see Figure 5). The mixed traffic often led to delays and a nearby neighborhood development seemed likely to worsen the existing congestion. The city wanted to separate out bicycle traffic in order to improve traffic flows at the intersection but recognized that people had safety concerns with the existing tunnels (Van den Bergh, 2019). Rather than going underneath car traffic as with the Bear Pit, people on bicycles approaching the Hovenring must climb up long ramps with grades up to three percent in order to cross above the car traffic (Peeters, 2011). During a community meeting prior to its opening, multiple seniors expressed concern that they would not be able to climb the approach ramps (Peeters, 2011) and after its opening the local paper reported that some older people taking alternative routes with level crossings (Peeters, 2012).
While the Hovenring may have reduced travel times for some cyclists, the flow of traffic for the cars below has improved considerably. For this reason, the local paper stated, “The Hovenring appears to be a great success… the social benefits – not even counting health, emissions, or fossil fuel use – have been calculated at around 300,000 euros per year in reduced travel time alone.” (Van den Bergh, 2019, p. 1) While the Hovenring’s most visible users are those travelling across its top, it is those travelling across the bottom that receive the intended benefits of faster connection times to the highway and airport. The Hovenring was designed to improve the system of automobility. Its success has been measured in terms of improved travel time for cars, reflecting a conventional approach to transportation planning (see Figure 2, question 2a). While the innovation allows the link in the cycling network to remain in place, its core purpose is not to advance cycling within the mobility regime, but to prevent people who are cycling from disrupting the efficiency of the automobility.

The Hovenring’s lack of support for a transition to sustainable transportation systems is placed into stronger relief through a comparison with another roundabout in another Dutch city: the bicycle roundabout in Zwolle.
4.2  THE ZWOLLE ROUNDABOUT: AN INCREMENTAL INNOVATION IN A HIGH CYCLING CONTEXT SUPPORTING SUSTAINABLE MOBILITY

While Eindhoven’s modernist planning principles have a long history of focusing on improving the system of automobility, the Dutch city of Zwolle has developed a reputation for advancing cycling within their mobility regime, winning the Dutch Cycling City of the Year Award from the Dutch Cyclists’ Union in 2014 (NOS News, 2014) and having been chosen as the second best city in the world for cycling by the organization People for Bikes, ahead of both Amsterdam and Copenhagen (People for Bikes, 2021). Their cycling rate is also considerably higher than Eindhoven’s, with 47% of trips being taken by bicycle (see Figure 4 and Figure 2, question 1) (KiM, 2014). The city of Zwolle’s commitment to the principles of sustainable mobility is reflected in their own innovative roundabout design. In 2012, the city installed a roundabout that gave cyclists priority over cars at all conflict points (Zwolle Cyclists’ Union, 2012). This was not new; people on bicycles already have priority over cars on 1,699 of the country’s 3,650 roundabouts (DTV Consultants, 2019). The roundabout in Zwolle, however, made an incremental change that made it the first of its kind in the Netherlands: it allows cyclists to turn in every direction while restricting car movements. This innovation allows people cycling, but not those driving, to continue along an important street in the city’s bicycle network (see Figure 6, inset) (Boschman, 2022).

Figure 6. A map showing in red the location of the bicycle roundabout in Zwolle, including an aerial photo of its design.
Unlike the Eindhoven roundabout, the Zwolle roundabout therefore unambiguously supports cyclists while restricting the system of automobility. It was designed specifically to reduce wait times for cyclists in a place where a significant number of cars crossed a street with heavy bicycle traffic (see Figure 6) (Van den Berg, 2018). Rather than separating the car and bicycle traffic by forcing an elevation change for the cyclists as with Eindhoven’s Hovenring, the Zwolle roundabout has people driving yield so that people biking can continue without any extra effort. This was done not only to improve conditions for existing cyclists, but to support the expected increase of future cyclists along the route. The solution was made possible by the strong support for cycling within Zwolle’s mobility regime as the Zwolle’s Cyclists’ Union was part of the roundabout’s development and implementation process (Zwolle Cyclists’ Union, 2012). After its implementation, the Dutch city of Veenendaal in the nearby province of Utrecht adopted the design for a similar situation, and the province has plans to implement the design in several other locations (Van Unen, 2020).

The Zwolle roundabout reflects an incremental innovation that succeeds in following the sustainable mobility paradigm through the support of cycling within the mobility regime (see Figure 2, questions 2a and 2b). The next section examines how a Dutch influenced roundabout in an entirely different institutional context functions a radical niche innovation even as it does far less to challenge the system of automobility.

4.3 THE SAN FRANCISCO MINI-ROUNDBOUGHT: A RADICAL NICHE INNOVATION IN A LOW CYCLING CONTEXT THAT SUPPORTS SUSTAINABLE MOBILITY

In March 2021, an innovative roundabout opened in San Francisco, California. With the design and implementation led by a transportation engineer who studied in the Dutch city of Delft, the intersection is based on the roundabouts commonly found in the Netherlands (see Figure 3) (Rudick, 2021b).

San Francisco has the largest city-based bicycle coalition in the United States (SFBC, 2017), is the founding city of the global cycling protest movement Critical Mass (Pucher et al., 2011) and San Francisco County has a cycling commuter rate nearly double of that of any of the surrounding Bay Area counties (Eisen Letunic, 2009). While the San Francisco metro area ranked second in the U.S. on a transportation climate impact index that examined how well U.S. cities supported sustainable transportation modes (Streetlight Data, 2019), the mobility regime of San Francisco still functions quite differently than in the Dutch cities with similar roundabouts. The SF mobility regime has a cycling mode share of only 2% and a driving mode share of 48% (Corey, Canapary, 2019) (see Figure 4 and Figure 2, question 1)). According to the intersection designer, this imbalance between automobility and vélocimobility in San Francisco resulted in two significant deviations from how this type of roundabout is implemented in the Netherlands.
First, the intersection is considered a mini-roundabout, a term that refers not to its size, but to the fact that it does not contain any raised elements. The lack of a raised element allows motorized traffic, particularly buses and larger trucks, to go outside any of the boundary markings in order to cross the intersection (see Figure 3) (Presidio Trust, 2021; Rudick, 2021b). Second, the roundabout does not give priority to people cycling. At points where bicycle and car traffic conflict, people on bicycles must make a 90 degree turn to a stop line, where they must yield to approaching car traffic (see Figure 7, inset) (Rudick, 2021b).

While these elements may seem to reflect a conventional approach to planning that supports automobility, the design’s fundamental purpose, stopping car traffic from travelling at unsafe speeds through the intersection (Rudick, 2021b), aligns with the sustainable mobility paradigm principles of slowing traffic down and improving accessibility for all road users (see Figure 2, question 2a). Further, in the specific context of San Francisco’s mobility regime, a roundabout that incorporates bicycle infrastructure fits the definition of a radical niche innovation in terms of both its novelty and its challenge to an established regime (see Figure 2, question 2b). While roundabouts that included separate cycling infrastructure became the recommended design nationally in the Netherlands in 1998 (Dijkstra, 2005), the city San Francisco has only one other roundabout and it does not have separate bicycle infrastructure; lane markings indicate that cyclists must share the space with cars (Bakali & Grant, 2014).

Figure 7. A map showing in red the location of the mini-roundabout in San Francisco, including an aerial photo of its design. The borders of the Presidio National Trust are outlined in blue. [aerial image from Presidio Trust, 2021]
San Francisco’s new roundabout is a radical niche innovation not only because it is new to the city but also because of how its implementation was realized outside of the established mobility regime: the roundabout is within the city limits of San Francisco but constructed on land belonging to the Presidio National Trust, a national park that independently maintains and designs its own roads (see Figure 7). As one local reporter noted, this means the project was not “beholden to the usual politics and pushback that comes with making changes to the street” (Rudick, 2021b, p. 1). For example, in 2018, the City of San Francisco removed a traffic circle that had been installed only six months earlier with the support of transit and pedestrian advocates after nearby residents complained honking coming from drivers not yet familiar with the design (Rudick, 2018).

While its existence within the protective space of a small planning department with a willingness to experiment allowed the roundabout to be implemented, its design was not exempt from the larger culture of automobility within the city. The application of strategic niche management principles was necessary in order adapt the innovation to mobility regime in which it was being implemented. (see Figure 2, question 2c) As stated by the designer, the intersection is “a very new concept for both cyclists and vehicles. It’s conservative, but we’re planning to look into the bicycle control more as the intersection settles in” (Rudick, 2021b, p. 1). The project leader began with a fit-and-conform approach (Smith & Raven, 2012) that adapted the roundabout design to the unchanged selection environment of a city unfamiliar with how to navigate roundabouts, with the ambition to change to a stretch-and-transform approach (Smith & Raven, 2012) as people in the city become more accustomed to this type of infrastructure. The project leader hopes to accelerate this process through discussions with traffic engineers from the city of San Francisco about how similar roundabouts can be implemented at intersections controlled by the city itself (Rudick, 2021b). Recently, the city has announced plans to construct a full-scale roundabout with priority for cyclists (Rudick, 2021a). Whether or not this plan is fully realized, the mini-roundabout on the Presidio National Trust land, and the adjustments made to it in response to a changing relationship between vélocity and automobility, serve as example that could support future upscaling outside of the boundaries of the Presidio National Trust land.

In form, the San Francisco mini-roundabout does not challenge automobility to the same degree as its well established Dutch counterparts or the incrementally innovative design found in Zwolle. Still, it functions as a radical niche innovation in the mobility regime where it has been implemented. The example demonstrates how an innovation that supports sustainability, even if it has become part of the landscape metaphorically and literally in one mobility regime, may need to recategorized and reconceptualized when implemented within a different mobility regime, with the elements that support a transition to sustainable mobility being identified and protected to the largest degree possible within the institutional context in which they are implemented.
5 DISCUSSION AND CONCLUSION

Through its novel and systematic application of the multi-level perspective, sustainable mobility paradigm, and strategic niche management principles, this article provided a framework for evaluating the relationship between cycling innovations and sustainability goals, and the implications of institutional context in the achievement of those goals. By combining principles of the SMP with transitions theories, the article contributes to the literature on the transition to sustainable transportation systems by providing a framework for understanding the role that cycling innovations play in transition processes. An analysis of the implementation of three comparable innovative cycling oriented roundabouts in three different mobility regimes demonstrated the practical application of this framework.

The analysis demonstrates how one general type of cycling infrastructure can have multiple possible outcomes for sustainability transition goals. The three cases that were examined through the lens of the evaluation framework presented here showed one instance of a cycling innovation advancing automobility, one instance of an incremental advancement in support of sustainability goals, and one instance of a radical niche innovations challenging the role of automobility. The analysis was able to show three different outcomes for a similar type of cycling innovation because the analysis did not begin with the assumption that all investments in innovations related to cycling support sustainable transition goals. Rather, the analysis examined the cycling innovation in the context of the specific mobility regime in which it was implemented in order to determine whether or not it supported a transition to sustainable transportation systems. This approach clarifies whether or not a cycling innovation is being used to support people who cycle in order to increase cycling rates or being used to manage cyclists in order to improve the efficiency of automobility. It also allows for an understanding of how a similar cycling innovation can be relatively uncontested as an incremental innovation in one mobility regime and undergo transformations as a radical niche innovation in another.

While the framework described in this article allows for an analysis of a cycling innovation within a mobility regime, understanding how similar cycling innovations can have different relationships to sustainability and require different adaptations in different mobility regimes is a necessary step towards understanding how cycling innovations that support sustainability goals can be adapted to successfully move between mobility regimes. In the past decade, multiple scholars expanded on the importance of placing increased theoretical emphasis on the role of geography in sustainability transitions (Coenen et al., 2011; Köhler et al., 2019a; Norcliffe, 2009; Raven et al., 2012; Truffer et al., 2015). These geographic considerations are of particular importance in considering the development and spread of cycling innovations. This is reflected by academic works that have looked at how differences in cycling rates between two places have led to differences in the adoption of cycling innovations in those places (Schwanen, 2015; Waes, 2021) and in studies that examine how places with low cycling rates can benefit from the innovations found in places with high cycling rates (Gössling, 2013; Pucher & Buehler, 2008). With further development, the framework presented here could be
used not only to understand how cycling innovations move across different mobility regimes, but also how they change and develop within a particular mobility regime when the dynamics between automobility and véломobility shift.

An increasing amount of attention is being given to the role cycling could play in promoting sustainable transportation systems in order to address the climate crisis (Bruno & Nikolaeva, 2020; Gössling, 2013; Gössling & Choi, 2015; Jensen et al., 2017; Larsen, 2017; McAndrews et al., 2018; Olmos et al., 2020). At the same time, a critical véломobility scholarship has emerged questioning the narratives around cycling and sustainability and analyzing the influence of automobility on the creation of effective cycling policies (Cox & Koglin, 2020; Freudendal-Pedersen, 2015a; Henderson & Gulsrud, 2019; Koglin & Mukhtar-Landgren, 2021; SPINNEY, 2022; Tschoernert-Budde, 2020), demonstrating the need for a critical approach in evaluating the relationship between cycling innovations and sustainability goals. As argued in this article, applying sustainability and transitions theories directly to cycling innovations allows for a better understanding of which innovations are most likely to support a transition to sustainable transportation systems.

Acknowledgments

The author would like to thank everyone who provided support in the development and revision of the article, with particular appreciation for the revision suggestions from the mobility researchers in the TIS group at Eindhoven University of Technology, including Ruth Oldenziel and Frauke Behrendt, and for the case suggestions based on their comprehensive local knowledge from my former colleagues in San Francisco: Brendan Monaghan, Jonathan Kibrick, and Ted Rosenblatt. The author assumes responsibility for all errors.

Funding

Matthew Bruno is supported by the VerDuS programme Smart Urban Regions of the Future with project number 438-15-160 which is (co)financed by the Dutch Research Council.
Chapter 3: Mobility Protests in the Netherlands of the 1970s: Activism, Innovation, and Transitions

1 INTRODUCTION

Many scholars consider the Netherlands’ current cycling policies and infrastructure a model for other countries looking to increase cycling rates as part of a transition to sustainable mobility systems (Harms, Bertolini, & Brömmelstroet, 2016; Pucher & Buehler, 2008; Pucher, Dill, & Handy, 2010). The current Dutch cycling rates, however, were largely established in the 1970s when a steep decline in cycling rates occurring across Europe and other parts of the world was halted in the Netherlands (see Figure 1) (Oldenziel, Emanuel, Albert de la Bruhèze, & Veraart, 2016; Reid, 2017). This stabilization of cycling rates occurred after broadly supported social movements, formed to protest the increasingly severe effects of rapid motorization, worked with a responsive government to introduce a series of innovations that supported cycling. If Dutch cycling policy is to serve as guide for sustainable mobility transitions elsewhere, these innovations that supported the change in cycling rates must be identified along with the conditions under which they were implemented. This requires understanding how innovations shaped Dutch cycling rates in a specific geographic and historical context.

Our paper contributes to the understanding of the geographic and temporal dimensions of sustainability transitions by examining the role of the 1970s mobility protests in The Netherlands in sustaining high cycling rates over the long term. Connected across Dutch cities and linked by a common legal and planning policy framework, the urban-based protesters worked with government actors to advance three cycling-supportive innovations: (i) the woonerf, a low-speed traffic environment discouraging through-traffic and eliminating distinctions between pedestrian and car space; (ii) car-restricted central business centers designed to limit car access while prioritizing pedestrians and cyclists; and (iii) the bottleneck-memoranda, a tool that relied on community participation in reporting obstacles to cycling. We argue that activism and protest provided critical support to innovations and the development of new governance models of citizen participation in the Netherlands in the 1970s. These innovations helped stabilize cycling rates by making cycling more convenient than driving and integrating consideration for cycling into local and national transport policies.

Our article shows how social movements can provide critical support for innovations not yet fully accepted by the public in a manner analogous to how applying strategic niche

management principles can protect promising sustainability innovations from potentially damaging market pressures (Kemp, Schot, & Hoogma, 1998; Raven, Van Den Bosch, & Weterings, 2010; Schot & Geels, 2008). Instead of focusing on the relationship between the market and the State, our article looks at the relationship between social movements and the State. It examines how Dutch protests in the 1970s led to a collaboration with government actors that facilitated the implementation of innovations that restricted car mobility. In other countries and in other contexts such implementation has been politically challenging (De Groot & Schuitema, 2012; Gärling, 2007; Keizer, Sargisson, van Zomeren, & Steg, 2019; Loukopoulos, 2007). We also analyze how this support for the car restricting policies has declined as the conditions that led to the social movement support, high pedestrian and cyclist injuries and deaths from car collisions, have changed. We will outline how this has led to a situation in which “for most Dutch, cycling is not remarkable enough to pay a lot of attention to” (Stoffers, 2012, p. 93). This has resulted in a shift in how the national government approaches cycling policy: while the social movement supported innovations of the 1970s placed restrictions on cars, later government-led policies have focused on promoting cycling without interfering with car mobility.

Even with cycling rates in the Netherlands having largely been stable over the past 50 years, concerns over car dependency have grown (Jeekel, 2011) and the Netherlands, like many other countries, has looked for ways to increase the mode shift from driving to cycling (Harms & Kansen, 2018; Kado, 2017; ter Avest, 2015; Van Boggelen, 2010). Our article concludes with a discussion of whether the Netherlands can achieve its own goal of increasing cycling rates by 20 percent (Tour de Force, 2017) without additional car restricting policies. It also discusses the challenge of using the Netherlands as a model for increasing cycling rates in countries with a low cycling mode share.

## 2 METHODS

Our research draws from ten in-depth interviews with key actors in the Dutch mobility protests of the 1970s, using a semi-structured format. The subjects reflected on their past experiences and shared their perspectives on their actions’ outcomes (see Appendix A for an overview of the interview questions).

To identify subjects that could inform our research about the activism from the 1970s to the present, we conducted a stakeholder analysis from a list of 37 potential subjects. The list was based on scholarship (Duizer, 2005; Valenta, 2013; and Berkers, Botma, and Oldenziel, 2018) in combination with the Cyclists’ Union Department Archives and recommendations from the interview subjects themselves. (See Appendix B for details).

For the historical context and results sections, we also draw on scholarship, policy documents, and archival material that provide evidence of the relationship between cycling activism and 1970s Dutch cycling innovations.
3 THEORETICAL BACKGROUND

Scholars have already argued that social movements can advance sustainability transitions independent of technological innovations (Cresswell, 2006; Roberts, 2020; Temenos et al., 2017). Through their reconstruction of the history of shared vehicles, Ploeger & Oldenziel (2020) have demonstrated how activism has shaped the innovation of shared mobility since the 1960s. Rather than focusing exclusively on innovation development, our article examines how social movements have been instrumental in the implementation and expansion of innovation. In much the same way that strategic niche management scholarship shows government and industry’s role in the creation of protective spaces to foster the spread of sustainability innovations (Barrie, Zwandie, & Joao, 2017; Smith & Raven, 2012; Verhees, Raven, Veraart, Smith, & Kern, 2012), we argue that the 1970s social movements played a similar role in providing protection and support for newly developed sustainable mobility supporting innovations in the Netherlands. This allowed government actors to rapidly implement them and integrate them into the Dutch mobility landscape.

The article discusses how these social movements were connected across Dutch cities and regions and how specific aspects of transportation policy and planning in the Netherlands facilitated the rapid spread of the innovations that these social movements supported. This relevance of geography to sustainability transitions has received increasing attention (Coenen, Benneworth, & Truffer, 2011; Norcliffe, 2009; Raven, Schot, & Berkhout, 2012; Truffer, Murphy, & Raven, 2015). Members of the Sustainability Transitions Research Network have highlighted the need for more research on the relationships between geography, history, and innovation concerning sustainability transitions (Köhler et al., 2019). Hansen and Coenen (2015) discuss the role of place specificity in sustainability transitions. They explicitly focused on urban and regional stakeholders but did not cover the relevance of social movements’ actions and interactions with the state actors within a defined geographic and institutional context.

In contrast to these innovation and transitions scholars, historians have noted the place-specific aspects of contemporaneous historical social movements in shaping cycling rates across major cities in different countries (Oldenziel et al., 2016). Bringing these two strands of scholarship into conversation with each other in this paper will lead to a richer understanding of transitions. Innovation scholar Shove (2012) argues that transitions literature needs to give more attention to “disappearance, partial continuity, and resurrection” (p. 363). Garud and Gehman (2012) propose what they refer to as “durational perspectives” (p. 980). The authors argue that “our journeys to a sustainable future may imply going back to practices that were shelved, abandoned or even stigmatized as mistakes” (2012, p. 986). Specifically, they outline the need for more research on the temporal aspects of sustainability transitions, noting that “the policies to take us forward may lie in the past” (p.989). Our paper accomplishes this through interviews with key actors that reflect on their past work in relation to present circumstances. Other scholars call for more research on the role of social movements over
time and how historical analysis can help with understanding the long-term impacts of protest (Amenta, Caren, Chiarello, & Su, 2010; Giugni, 1998).

Our historical analysis suggests that the large number of existing cyclists, and their pressure on the government for better cycling conditions, provided critical support for the widespread implementation of innovations that resulted in car-restricting infrastructure, an approach that has been shown to politically unpopular and difficult to implement in other contexts (de Groot & Schuitema, 2012; Gärling, 2007; Keizer et al., 2019; Loukopoulos, 2007). It provides a counter-narrative to the often alluded to axiom of cycling infrastructure “if you build it, they will come” (Félix, Cambra, & Moura, 2020; Krizek, Poindexter, Barnes, & Mogush, 2007; Lugo, 2013; Porter, Suhrbier, & Schwartz, 1999). The substantial number of cyclists still present in the 1970s (see Figure 1), and the social movements that they supported, were critical in developing the woonerf, the car-restricted city center, and bottleneck memoranda. These three cycling-supportive innovations spread across the Netherlands around the same time.

Finally, we discuss the implications of the decline of those social movements’ influence as policymakers look for innovative ways to increase cycling rates further. This contributes to the discussion begun by Shove and Walker (2007) on the complexities of citizen involvement in sustainability transitions and the limits to shaping transition processes.

4 Historical Context

With a mode share of approximately 27 percent of trips (BOVAG and RAI Vereniging, 2016), the Netherlands has the highest cycling rate in Europe (European Cyclists’ Federation, 2015). Historically, however, many European cities had comparatively high cycling rates that declined rapidly between the 1950s and the 1970s, with rates in Dutch cities dropping later and less dramatically than other European cities (see Figure 1). The reasons behind this divergence are complex. Historians have identified multiple causal factors, including differences in the Netherlands in the urban landscape, the availability of alternatives to cycling, how cycling was integrated into traffic policy, and differences in the cultural status of cycling, but also the differing impact of social movements across countries (Oldenziel et al., 2016). This section provides a brief overview of the role the Dutch social movements of the 1970s had in shaping mobility in the Netherlands.
As elsewhere, in the late 1960s, protest movements against the negative effects of capitalism on issues like the environment and traffic emerged in the Netherlands. Provo (1965-1967) and the Kabouter (Gnome) movement (around 1970) were among the earliest organizations involved in these protests (Kennedy, 1995; Mamadouh, 1992; Otten, 2017; Pas, 2015; Van Duyn, 1985). The Kabouter movement objected to the amount of space given to the car and the resulting air pollution. Provo activists were the first to bring attention to traffic problems and safety in the Netherlands (Furness, 2005). Their White Bicycle Plan, considered the first shared bicycle scheme (Ploeger & Oldenziel, 2020), was created to criticize the car’s polluting and space-consuming role in the city (Feddes & De Lange, 2019; Furness, 2010; Mamadouh, 1992; Van Duyn, 1985).

The critical values that Provo, Kabouter, and other similar movements represented were the same ones that later action groups took up in the 1970s: an emphasis on self-governance; livability; the small (neighborhood) scale, which prioritized walking and cycling over driving; and opposition to unrestricted economic growth and city center redevelopment to accommodate big business and cars (Mak, 1992; Schumacher, 1973).

Broad support for protesting the car was directly related to the rapid motorization occurring in the Netherlands and the rising danger and disruption of cyclists. While present-day Dutch car ownership levels are in line with other European countries, before the late 1960s, the levels lagged behind those of surrounding countries. In 1960, the Netherlands had 45 cars per 1000 inhabitants, half that of Belgium (82) and Switzerland (89). By 1970, however, Dutch car
ownership reached similar levels to those of Belgium and Switzerland: about 200 cars per 1000 inhabitants (Filarski & Mom, 2011; Wolf, 2010). This increase in Dutch car ownership is partly attributable to the relatively late abandonment of the postwar policy of controlling salaries in the Netherlands in the early 1960s, creating a sudden increase in the purchasing power of many households (Oldenziel et al., 2016).

This sharp and sudden motorization took place within a context of a large (urban) cycling culture, creating pressure on public space in cities. While the high cycling levels of the 1950s dropped in the 1960s and reached a nadir around 1970, in many Dutch cities, the bicycle still had a substantial mode share of roughly 30 percent (see Figure 1).

One consequence of the rapid increase in car ownership was a substantial growth in the number of people, specifically children, being killed or injured by cars. Between 1950 and 1970, the number of children under 14 suffering from car related injuries annually almost doubled from 278 to 460 [see Figure 2]. The number of cyclists of any age killed in traffic saw a similar rise within the same period, going from 332 in 1950 to 512 in 1970 [see Figure 3].

In response, activist groups began to form to oppose the increasing risks brought about by the car’s transformation of the city. In 1971, the Dutch journalist Vic Langenhoff lost one of his children in a traffic incident and then dealt with another being injured just a few months later. He published a piece in a national publication called Stop the Child Murder [Stop de Kindermoord] describing his own experience and relating it to what was happening throughout the Netherlands (Langenhoff, 1972a, 1972b). A group of activists in Amsterdam took the name for their organization and promoted actions to bring awareness. They occupied sites where people had been killed in traffic incidents, organized street traffic closures to create play space for children, and held demonstrations on bicycles (Van der Zee, 2015).

Around the same time, in 1970, a group of architecture students at the Rotterdam Architecture Academy started a working group in the nearby city of The Hague. They criticized the plans to tear down the city’s existing fabric to make room for highways and parking garages (The Hague City Archives, 1985). The group called themselves Dooievaar, a pun that combines the Dutch word for dead, dood, with the word for the Hague’s symbol, the stork, Ooievaar (Hoogland, 2017), into “dead stork” (Berkers, Botma, & Oldenziel, 2018).

Dooievaar believed in citizen participation: community members should be allowed to comment on already developed plans and be included earlier in an open discussion about the plans' underlying assumptions and objectives (Oorschot, 2014b). To address that, the group conceived a protocol to gather information from users to facilitate planning, so-called bottleneck memoranda, discussed in the next section.

These two groups, Stop the Child Murder and Dooievaar, were far from the only activist groups formed to advocate for a different approach to transportation planning. In mid-1970s, the formation of a progressive ruling coalition in the Dutch parliament coincided with a transnational wave of environmental activism brought into action in part by the publication of the Club of Rome report “The Limits to Growth” and the oil crisis (Cramer, 1989; The Club of
One of the forms that this global movement took in the Netherlands included multiple groups dedicated to cycling advocacy, demanding safer streets, a more responsive government, a more significant concern for the environment, and improved cyclists’ facilities. In 1975, these groups united to form a national Cyclists’ Union [see Figure 2].

In the interview excerpts in the sections that follow, the activists involved with these groups and the civil servants who responded to their demands describe their motivations and experiences and the long-term impact of this period on cycling in the Netherlands.

**Founding Members of the Dutch Cyclists’ Union**

<table>
<thead>
<tr>
<th>National Groups</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Workgroup 2000 (1965)</td>
<td></td>
</tr>
<tr>
<td>Environmental Defense Association (1971)</td>
<td></td>
</tr>
<tr>
<td>Nixen (1960)</td>
<td></td>
</tr>
<tr>
<td>Strohalm (1970)</td>
<td></td>
</tr>
<tr>
<td>Stop the Child Murder (1973)</td>
<td></td>
</tr>
<tr>
<td>Rover (1971)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Local Groups</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Auto-free Amsterdam (1974)</td>
<td></td>
</tr>
<tr>
<td>Wrong Traffic Amsterdam (1973)</td>
<td></td>
</tr>
<tr>
<td>Wrong Traffic Utrecht (1973)</td>
<td></td>
</tr>
<tr>
<td>ENWB Utrecht</td>
<td></td>
</tr>
<tr>
<td>Lelien Bicycle Workgroup (1973)</td>
<td></td>
</tr>
<tr>
<td>Doolewaar (1972)</td>
<td></td>
</tr>
<tr>
<td>Rotterdam Bicycle Working Group</td>
<td></td>
</tr>
</tbody>
</table>

Figure 2. Founding Members of the Dutch Cyclists’ Union. Information compiled by Henk-Jan Dekker for his dissertation Cycling Citizens: How Cycling Survived Politically in the Netherlands, 1880-2020, forthcoming. When noted, the year given denotes the earliest year in which evidence of activity is available. In some cases, the official founding may be a year later and the origins may be earlier. Netherlands Map by Vemaps.com
Figure 3. Number of young people and cyclists killed in traffic, 1950-2016. Data from Stichting Wetenschappelijk Onderzoek Verkeersveiligheid SWOV. See: https://www.swov.nl/feitenencijfers/verkeersveiligheidscijfers-verkeersongevallen [accessed 02-12-2019]

5 RESULTS

The social movements of the 1960s and 1970s fought against the negative effects of motorization and for the reclamation of space for other road users. These movements arose from two factors linked specifically to this period in the Netherlands: a general climate of activism; and rapid motorization that effected people’s sense of safety and well-being, as described above. Understanding how these factors led to long-term changes in Dutch cities requires an explanation of a third historical element: the development of specific innovations in policy, design and governance that made streets safer for pedestrians and cyclists by reversing policies implemented to improve car mobility. Using information from interviews alongside supporting sources, the subsections that follow outline three issues: the development of these innovations, how activists were able to work with institutions to implement them, and the implications of the decline the in activism that supported these innovations.
5.1 INNOVATIONS IN RECLAIMING CAR SPACE FOR CYCLING

5.1.1 The bottleneck memoranda
One of the broader movements’ goals, including Dooievaar, was to find ways to shift the balance of power back in favor of cyclists. They wanted to reclaim road space for cyclists. As Hans van Beek, a founding member of Dooievaar, described in his interview:

*We wanted to give [cyclists] the rights which they had before and the more [the city] facilitated the car system, the less the space there was for the bike.*

Practically, this meant addressing the numerous small obstacles to cycling that the expanding car infrastructure had created. Dooievaar did this through the bottleneck memoranda, a social innovation (Henderson, 1993) in the form of a governance tool that begins with a report based on users' information. This activist group of young architects and engineers encouraged cyclists to report problems and bottlenecks on their cycling route. Later, the group compiled all the reported obstacles into a document that became the basis for a new bicycle plan for the Hague, proposed by the Dooievaar group in 1973. As Hans van Beek recalled:

*After consultations with people where we asked, “What are the places that bother you when go to work?”, we made a kind of town plan with this knowledge and that [plan] restored not only possibility of cycling, but... gave [cyclists] the main roads where they would have priority.*

The plan included redesigning the traffic system to accommodate cyclists better, removing parking to create bike lanes, and changing signal timing to prioritize cyclists at specific intersections (Werkgroep Dooievaar, 1973). They also devised a do-it-yourself manual for local activists who wanted to design an urban cycling path network (Stop de Kindermoord, 1975). It demonstrated how an ideal cycling route network could be drawn up with everyday cyclists' input and included a detailed and knowledgeable breakdown of the inner workings of local city bureaucracy and politics. In this way, other activists received valuable pointers on engaging the local citizenry and politicians in a conversation about better cycling facilities.

Leo Hamer, another of Dooievaar’s founders, described the processes behind the original bottleneck memoranda. He pointed out that the governance innovation of listening directly to cyclists also resulted in policy innovations, for example, the differentiated rule for cyclists on one-way streets:

*There was a bridge over the canal. And that was one direction... so we suggested to make it one way for the cars but not for the bicycles...so it was easier to move by bicycle [across the cities] and, on some streets, there were blockades for cars.*

This proposal led to cyclists' exemption to ride both ways on one-way streets, allowing two-way traffic for bicycles on streets that had one-way for cars. It became a broader policy of exempting cyclists from one-way street regulations, including official traffic signs that designate where this practice is allowed (VVN, 2021).
In 1974, Dooievaar worked with a community group to implement the ideas from a bottleneck memoranda on two streets in the Hague (Oorschot, 2014a). By 1976, the cyclists’ unions in the Dutch cities of Amsterdam, Arnhem, Amersfoort, Delft, Enschede, Haarlem, ’s Hertogenbosch, Maastricht, Rotterdam, and Utrecht had produced similar reports (E.N.W.B. Utrecht, 1976). Bottleneck memoranda became a standard part of the toolkit for the Dutch Cyclists’ Union (Stichting Fietsersbond, 2021). In 2012, the national government released a plan to create a bottleneck memorandum for every municipality in the Netherlands (Trouw, 2012).

5.1.2 The woonerf

Another innovation designed to slow down car traffic and reclaim space for pedestrians and cyclists was developed around the same period: the woonerf. Maartje van Putten, who founded Stop the Child Murder in Amsterdam as a young mother, described the meaning of the Dutch word for this innovation in public space:

An erf is an area where the chickens walk around, and cat and dog and a cow maybe, an old-fashioned word for the space around a farmhouse. A woonerf is a living erf.

In the late 1960s, Niek De Boer, an urban planner working for Emmen’s city, designed this type of street-based on the co-existence between cars and other road users (Schoorl, 2015). The woonerf prioritizes pedestrians and creates a low-speed traffic environment by eliminating distinctions between pedestrian and car space and using non-linear street designs, plants, and street furniture to prevent high-speed traffic (Appleyard, 1980).

In 1969, while De Boer was developing the woonerf concept, the city of Delft was working on a redesign project for streets in the city’s low-income neighborhoods. The city adopted De Boer’s ideas to create new play areas where new sites for playgrounds were challenging to find. The design became a success and was incorporated into the Dutch traffic code in 1976. By 1990, there were over 3,500 woonerfs in the Netherlands and neighboring Germany (Ben-Joseph, 1995).

André Pettinga, a former civil engineer for the city of Delft who worked on the woonerf concept at the time of its introduction in the city, discussed how the woonerf arose out of the growing concerns around the externalities of motorization. He also asserts how the rather simple concept reflected a fundamental change in thinking about street design:

The hook to do something in political terms… was road safety. The speedbump was invented, was introduced in Delft, before the woonerf, but later it became a standard part of the woonerf. The same with the chicanes and the narrowing of the streets, the narrowing of the crossings and the junctions. In all standard books for engineers, there were big junctions… with wide streets and wide curves. It was really revolutionary to make it small.

As Steven Schepel explained when describing the original report that outlines the principles for woonerfs, reducing car speeds was not the only goal. Those advocating for more pedestrian and cyclist-friendly neighborhoods also recognized that their goal of shifting the balance away from car mobility could not be achieved if everyone could park directly outside of their home:
The report on traffic calmed residential areas went further in addressing parking... as a street that was completely full of parked cars could never be considered traffic calmed... This meant that you would probably have to park at some distance from where you lived.

Having a bicycle immediately accessible and a car some distance from the house increased the bicycle's comparative efficiency. Cycling became particularly efficient when traveling to city centers, where another innovation was also shifting the balance between cars and bicycles.

5.1.3 Car restricted city centers
In the mid-1970s, around the same time that the woonerf was being incorporated into the Dutch traffic code, another dramatic change was occurring in many Dutch cities. Municipalities ceased to turn their historic squares into parking lots and began restricting cars’ movement through city centers. For example, in 1974, the city of Utrecht began a long-term incremental approach to create car-free cycling routes by gradually decreasing the number of through routes for cars (Oldenziel et al., 2016). In 1975, the city of Groningen developed a similar plan that included the innovation of dividing the city center into quadrants that bicycles could move between, but cars could not (Dijksterhuis, 1976). In 1975, the Enschede city council voted to remove cars entirely from their city center, in part due to the advocacy of a local urban planner who had been influential in implementing woonerfs throughout the city (Oldenziel et al., 2016). The Netherlands largest city, Amsterdam, adopted its own set of car-restricting policies in 1978 (Oldenziel et al., 2016) beginning a long-term process of reducing car traffic in the city center, with a new comprehensive plan for traffic calming being adopted in January 2020 (City of Amsterdam, 2020).

Several interview subjects expanded on how this change came about, noting that it did not come immediately or without a great deal of effort. They indicate that the initial push for restricting cars in city centers came from a similar source as the support for the woonerfs, a desire to counter the negative effects of motorization.

As Jan Ploeger recalled:

[The idea for limiting car access to the city center of Groningen] was introduced by the PvdA, the socialist party. There were very young deputies and they said “We want to sit in the market and we don’t want that smell of cars and the noise of cars and we like to drink our glass of beer and have a good talk.”

While the initial push may have come from a frustration with the air and noise pollution, Hugo van der Steenhoven, a former city alderman for city of Utrecht and head of the Dutch Cyclists’ Union from 2003-2015, argued that continued support of the car restricting policies in city centers has come from the economic success of the businesses in these areas. He stated that:

In the 1950s and 1960s, we had the metal industry and blast furnaces here in Utrecht...[Businesses] that really depended on the car, they moved out of the city center and to the edge of the city... The city centers that are more or less car free, they are booming economically... Utrecht, Amsterdam, Den Bosch... they are the best shopping cities because
people like to walk around, and it’s not only the shops, it’s the atmosphere in the city. You can eat, drink coffee, go to the movies, go to theater.

City centers where it was difficult to drive and neighborhoods where it was safe to cycle produced such a favorable condition for cycling, that even people who had access to a car continued to cycle. The lack of car access to city centers also made cycling potentially faster than driving, and the prices of car parking making cycling cheaper.

Hans van Beek explained that cars' limitations are not the same as banning them entirely or compelling everyone in the city to ride a bicycle. Car restricting policies allow cities to shift the modal split in areas where large amounts of car traffic are considered undesirable:

Of course, some people will never ride a bike and never use public transport because they only want to use the car…in fact, it’s a system. The use of the bike is easier, and the good use of the car is...difficult, especially if you go to a very concentrated area.

Creating a transportation system where the bicycle remained useful, even as the car’s influence grew, required the support of institutional actors. The next section describes how activists leveraged broad public support and particular aspects of Dutch transportation planning protocols. Also, by working with the State, the activists allowed these innovations to spread rapidly across the country.

5.2 INSTITUTIONAL SUPPORT FOR PUBLIC SPACE INNOVATIONS
As described by the interview subjects, the new concepts for reclaiming public space were implemented and institutionalized within the Netherlands with State actors’ assistance. The study of planning documents from 1960-1980 by the historian Verlaan’s (2021) found that planners and traffic engineers in the Netherlands had more ambivalent feelings about changing cities to accommodate cars than their counterparts in England, France, or the United States. Nearly all the interview subjects reflected on the willingness of institutional actors to both consider and support activists’ ideas for mitigating the negative effects of increasing auto ownership.

As Maartje van Putten explained:

Can you imagine in those days that we, as young parents and me still being a student, were asked by the Ministry of Transport and Traffic Safety to come to meetings with officials to talk about [the need for safer streets] and to design draft legislation?...We were invited by members of the national parliament so we went to the Hague sometimes, with 30 children outside singing songs, and we were getting a cup of coffee or tea with members of parliament and discussing with them the situation and that something had to change. And it was all very open.

Similar to what Pettinga recalled for the woonerf design process, Maartje van Putten also points out that traffic safety was perceived as relevant regardless of political orientation:
We realized we were rather popular because everybody recognized it [the need to drop children traffic fatalities]. The issue was non-political. So, we were not made into a sort of struggle between left and right or what have you. Everybody was agreeing on the issue...

André Pettinga also experienced a government’s willingness to fund groups opposing the negative effects of motorization. He describes how the issue of traffic safety motivated people in the government to work with activists:

It started with traffic safety because... there was an urgency. You could no longer ignore it... If there is no problem, they don’t spend money. But there was... and there is not any politician, local, regional or central, or whatever politician who can ignore people killed or wounded... You can ignore the climate discussion or even deny it but you can never deny statistics on killed and injured people.

Jan Ploeger described his experiences working on cycling issues while a member of the Cyclists' Union in Delft around the same time as Pettinga. He explained that the large number of people who continued to cycle in the Netherlands at that time provided broad enough support for groups that proposed to reclaim space from cars. It helped overcome any resistance presented by automobile clubs:

In Delft we had contact with the local parties who joined [the cyclists' union] and who liked to have our support... and we organized this voting power as people who wanted back space for cyclists. And we discovered that it was a broad group of people who joined us... It was not only left focus, it was also from all parties, they joined us because they liked cycling, it was handy in Delft to have a bicycle and the focus was pollution, and loudness and all the disadvantages of the car.

Steven Schepel, who worked on the original woonerf project in Delft before chairing Stop the Child Murder in Amsterdam, recalled that the Dutch government was open to listening to their concerns and funding their group and willing to act themselves. Schepel informed that Stop the Child Murder advocated lowering the speed limit in neighborhoods and that there were specific aspects of the Dutch traffic code that made that change surprisingly easy to implement. For example, he pointed out that the existing legal framework for implementing a 30 km/h speed limit during road repair allowed the speed limit in neighborhoods to be dropped from 50 km/h to 30 km/h. He also stressed that ease of the process:

A 30 km/h limit was for temporary circumstances but then we thought it might be possible in residential areas... to implement that lower limit there. To our surprise, the ministry quickly latched on to our idea and said, “Yeah, that’s great, good plan.” And from that moment it became possible, it was a relatively simple change. It didn’t have to go through parliament as it was something the minister himself could set as policy.

The woonerf was more complicated than a simple lowering of the speed limit because of the functional elements and the legal aspects. Nonetheless, the particular way innovative street designs can be implemented in the Netherlands made their rapid introduction and also spread relatively easy. As Steven Schepel described:
The Netherlands has a tradition that the government agency responsible for a road can determine for themselves how that roads will be laid out and there aren’t many restrictions on how that can be done. Certainly for national highways and the national agencies there are indeed rules and as the provinces want to have uniform roads, they have more or less the same rules, but when it comes to neighborhood streets, the city can decide how they will look...and that means that some things are easier to implement in the Netherlands.

In 1990, in the context of a proposal to implement a comprehensive decentralization process planned for the mid-90s, the Ministry of Traffic and Water Management launched the Bicycle Master Plan (Directoraat-generaal Personenvervoer, 1997). After this project, which received the equivalent of approximately 15 million Euros in funding and was supported by the Dutch Cyclists’ Union, bicycle planning would primarily become the responsibility of provincial and city governments (Directoraat-generaal Personenvervoer, 1998). The national government wanted to ensure that, even after it was decentralized, cycling policy would still receive sufficient attention at other government levels (Ministry of Transport Public Works and Water & Management, 1992).

The post-evaluation found a significant change in how cities in the Netherlands approached cycling. Of the 19 cities evaluated, 16 put an increased focus on cycling policy after the Bicycle Master Plan. Also, none of the assessed cities had reduced their attention to cycling infrastructure (Bruno & Nikolaeva, 2020; Directoraat-generaal Personenvervoer, 1998). By the end of the plan’s implementation, cycling fatalities in the Netherlands had dropped to nearly a third of what they were at their peak in the 1970s [see Figure 3].

In this way, the freedom that municipalities had to redesign local roads enabled the spread of car restricting innovations in the Netherlands. Also, the investments and articulation from the national government promoted cycling policies locally. The outcomes of the investments and implementing the innovations discussed in this paper were general improvements for cycling, particularly the increase in safety and space to ride. This progress, however, ultimately resulted in the decrease in activism, thus less support from civil society, and in a corresponding decline of institutional support for these types of innovations, which is discussed in the next subsection.

### 5.3 The Decline of Institutional Support for Placing Restrictions on Car Mobility

Duizer (2005) describes the history of the Dutch Cyclists’ Union and denotes the period between 1979 and 1988 as declining membership and declining activism. In this period, their membership dropped from nearly 20,000 to 13,000. At the same time, the Union chose to work alongside government actors to develop and implement bicycle policies. This collaborative approach resulted in a drop in confrontational tactics (Tilly, 2006) and a reduction in the protests against the effects of increasing car traffic.
Several of the interview subjects pointed out a connection between the increase in cyclists' safety and the general decline of cycling activism in the Netherlands. For example, Peter Plantinga, a founding member of Eindhoven chapter of the Dutch Cyclists’ Union, said:

*Although stable, certainly [the Dutch Cyclists’ Union] is not growing now. You can see it in two ways. Young people don’t join so many of these organizations anymore. It could also be that we have been relatively successful. Most people joined [in the 1970’s] because they were annoyed about how things were going, so if there is less annoyance…*

Koos Louwerse, a cycling consultant who worked on the Bicycle Master Plan in the 1990s, articulated a similar idea:

*Now [cycling in the Netherlands] is still a bit unsafe, but there are not nearly so many deaths [as before], so the feeling of not being safe is there, but it is not so great that it’s leading to the creation of activist movements.*

Several of the interview subjects also noted that the decline in activism has also been accompanied by a decline in government money spent on cycling policies and projects. As André Pettinga stated:

*There is only research money [for a certain issue] in the cities if there is a political reason for that. If there is not a political issue, they don’t spend money on research.*

The government’s current national cycling policy project, Tour de Force, aims at coordinating cycling policy at a national level. It has a stated goal of increasing the number of kilometers cycled by 20% between 2017 and 2027 (Tour de Force, 2017). The project includes innovations such as traffic signals that give cyclists shorter wait times without disrupting car traffic flow (Hendriks, 2018) and bicycle highways that allow for faster travel by bicycle (Liu, Te Brömmelstroet, Krishnamurthy, & Van Wesemael, 2019). Koos Louwerse made a more specific comparison between Tour de Force and the Bicycle Master Plan, particularly about the difference in public funding for cycling:

*If you look at the size of a program like Tour de Force from the perspective of the Bicycle Master Plan… there is no comparison [...]. The Bicycle Master Plan received millions in funding, yearly, for an incredible number of projects (research, pilots, campaigns), all subsidized by a very active ministry. With Tour de Force, the ministry initiated and has worked on it and makes use of it, but the contribution to the program is much smaller: about a quarter of a million yearly. And when we compare the annual investments on infrastructure by the ministry … what is 25 million for the bicycle in comparison to billions for public transportation and cars?*

In addition to the decline in funding, Koos Louwerse also argues that the lack of car-restriction policies that will also hamper cycling goals. He argues that restraining car use is also necessary to increase cycling rates:

*The best bicycle policy is ultimately anti-car policy. There are a number of pro-bicycle and various things with the bicycle that are really great but… you are not going to get anywhere
without making car use less attractive. That means where you can drive and the price of parking.

Car-restrictions and reclaiming the streets were central to the outputs and outcomes of activists in prior decades. Nevertheless, many interview subjects described the present-day situation as one in which the limit for broad political support for cycling are measures that may interfere with automobility. As Hugo van der Steenhoven stated:

*On a national level, even the right-wing parties are in favor of cycling but when it comes to cars, then it’s over. As long it isn’t a problem for car mobility, they are in favor of cycling. The prime minister is always on his bike. And he’s very “I’m for cycling” but they don’t want to do something against car mobility.*

A statement by Wim Bot, a former city councilor in Delft and current senior policy advisor for the Dutch Cyclists’ Union, reflects this same idea of broad support for approaches to improving cycling that does not put restrictions on cars. He described how this political dynamic is reflected in the current approach of the Dutch Cyclists’ Union:

*In the Netherlands, there are no political parties that are against the bicycle... Sometimes they are not particularly for it and more for the car but ideologically it is not a point of contention. That is an enormous difference between the 1970s but also with the situation in most other countries. [In other countries], the cyclists’ unions are often a part of the alternative environmental sustainability movement and in the Netherlands, we always keep a certain distance from that.*

It is also noteworthy that the Dutch Cyclist’s Union currently also seeks a non-contentious position. As Wim Bot indicated, the organization tries to avoid conflict that could cost political support:

*We work together where we have positions in common but we also take great care that we don’t weigh in on the left/right scale because that would not do us any good. In addition to the environmental movement and air quality, we also co-operate on issues like providing more playing space and green in the city, but we don’t take part in any primitive anti-car positions.*

Hugo van der Steenhoven discussed how the relationship between car mobility and cycling is central to bicycle policy, but one that has become more difficult to address:

*The big discussion is always, can you push car mobility back? Can you get more space for cyclists and pedestrians instead of space for cars? ... Holland is ... a cycling country but it’s also a car[-oriented] country. And a lot of people are in their cars when they travel... small distances. You can easily cycle but it’s very difficult to persuade those people to leave their cars and take up cycling.*

While the demands for cycling policies were initially well aligned with other issues such as safety, particularly concerning children, as traffic-related deaths dropped, the issues lost the alignment. Consequently, the funding and the openness for car-restriction policies were also
reduced. As the discussion section describes, this has had implications for achieving the cycling rates that the Netherlands hopes to realize.

6 DISCUSSION

The outcomes that followed Dutch activism in the 1970s suggest that car-restricting policies have a significant role in facilitating cycling. Following this period, the interview subjects noted that as the number of traffic-related injuries and deaths declined so did civil society’s political commitment to engage in activism and of State actors to provide funds and implement car-restricting policies. The Tour de Force program, for example, has the potential to benefit people who cycle but avoids approaches that would take space from cars as those policies tend to be politically unpopular (de Groot & Schuitema, 2012; Gärling, 2007; Keizer et al., 2019; Loukopoulos, 2007).

Interviews with people directly involved with the development of these innovations in the Netherlands indicated that these types of policies were only possible under a particular set of historical and institutional conditions. In the 1970s, there was still a remarkably high number of cyclists in the country and a near-universal concern over the high rate of car-related injuries and deaths. Also, the Dutch governance system enabled the implementation of these innovations. They also became integrated and remained present in Dutch planning, even as the political support for car-restricting policies declined.

This narrative raises two crucial questions: (1) if car-restricting innovations played a key role in sustaining the current high rates of cycling in the Netherlands, can the Netherlands grow its cycling rates without further restrictions on car mobility; and (2) if having a large number of existing cyclists allowed Dutch activists to implement critical innovations in the 1970s successfully, can countries that have already experienced a substantial drop in cycling rates use the Netherlands as a model for how to grow cycling rates through similar car restricting innovations?

The study presented in this paper shows that the process in the Netherlands was based on a robust civil society, had broad public support, and a favorable institutional context. Reflecting the call for more research on the historical and geographic aspects of innovations that support sustainability transitions made by Köhler et al. (2019), further research is necessary to understand the historical and geographic conditions that allow for implementing car-restricting innovations and whether or not mature cycling countries (Harms, Bertolini, & te Brömmelstroet, 2014), such as the Netherlands, can expand their cycling rates if there is a diminished level of support for car-restricting approaches.

Also, the Netherlands’ cycling rates are currently high not because there was a growth in bicycle use but rather from halting a substantial decline since the 1970s. There has been a modest growth in cycling rates over the past two decades in the country. However, these changes still came from a position where bicycle use was already substantially higher than in other countries (Harms et al., 2014). Countries with cycling mode shares of less than 5% look
to the Netherlands for ways to shift people from driving to cycling. However, the last time the Dutch raised its cycling rates to above 5% pre-dates the car’s invention (Oosterhuis, 2016). Given this, it is also not clear if the cycling policies of the Netherlands in the present can serve as a helpful model for countries with low cycling rates aiming at increasing bicycle trips to support a transition to sustainable mobility.

Those advocating for cycling policies worldwide often invoke the motto “If you build it, they will come” (Félix et al., 2020; Krizek et al., 2007; Lugo, 2013; Porter et al., 1999). The idea is that simply offering safe cycle infrastructure will lead to an increase in cycling rates. The implementation of cycling supportive innovations throughout the Netherlands and the corresponding high cycling rates (Harms, Bertolini, & Te Brömmelstroet, 2014) seem to demonstrate this principle. However, an examination of how these cycling innovations became widespread suggests that the process is more complex. The demands from activists when cycling rates were already high – thus with cyclists on the streets to support their demands – led to the expansion (and proposals) of innovations, rather than the expansion of innovations leading to high cycling rates. Also, the history of cycle activism in the Netherlands suggests that offering cycling space is just part of the solution and that cars’ restrictions were crucial for the outcomes because it made cycling more convenient than driving, particularly for nearby trips to city centers.

The interviews reflected the role of activists in expanding and proposing innovations that allowed high cycling rates to persist in the Netherlands. While the high cycling rates in the Netherlands were supported by car restricting innovations, the innovations came about through the demands, support, and proposals of those who wanted to cycle safely. Understanding the successful implementation of innovations in sustainable mobility demands further attention to local activists’ role in shaping innovations. In general, more attention to the role of history and geography is needed for understanding and advancing a transition to sustainable transportation systems. The debate presented in this paper raises questions about whether countries looking at the Netherlands as an example should only copy the infrastructure that the Netherlands has built or also look for ways to support their own activists’ groups that are demanding better cycling conditions and who may be advocating for novel approaches entirely different from those found in the Netherlands.

7 CONCLUSION

In the 1950s, the high rates of cycling in the Netherlands and other parts of Europe began to drop rapidly. The process originated in the growth of auto ownership and investments in policies for automobiles. The negative externalities – e.g., air pollution, traffic-related deaths, and city-altering infrastructure projects taking space from cyclists – mobilized local civil society to challenge this course of action. Our paper contributes to the understanding of the geographic and temporal dimensions of sustainability transitions by showing how, through the support and proposal of innovations, activists in the 1970s played a crucial role in stopping the steep decline of cycling as a form a sustainable transportation. With this, the Netherlands
maintained bicycle trip rates higher than the surrounding European countries (see Figure 1). The activists provided support for two car-restricting innovations – the woonerfs and the car-restricted city centers – and proposed the bottleneck memoranda – a social innovation that aided the planning process. These measures halted automobility policies’ advancement, countered its negative effects, and helped reclaim space from cars. By creating safe spaces to cycle, these innovations promoted cycling and contributed to the long-term stabilization of cycling rates.

Acknowledgements

The authors would like to thank everyone who provided support in the development and revision of the article, including Frauke Behrendt, Ruth Oldenziel, and all the members of the Sustainable Urban Mobilities research team. The authors assume responsibility for all errors.

Funding sources

Matthew Bruno is supported by the VerDuS programme Smart Urban Regions of the Future with project number 438-15-160 which is (co)financed by the Dutch Research Council.

Henk-Jan Dekker is sponsored by Eindhoven University of Technology, Rijkswaterstaat and Pon Holdings.

Letícia Lindenberg Lemos received a Fellowship from FAPESP (São Paulo Research Foundation), process number 2017/11198-7, for carrying out this research at Eindhoven University of Technology as part of a more extensive Ph.D. project at the Department of Architecture and Urban Planning, University of São Paulo.
Appendix A: List of Interview Questions

**Personal background**
Could you describe how you became active in issues of mobility?
How long did you remain active/why did you leave?

**Activism**
What were the main goals you wanted to achieve?
What were the forms of action you chose to achieve this? Why those and not others? Range of action: Were they more protest- or more expertise-based? Proximity politics? Occupying offices?
Were you in contact with other activists?

**Governance**
With what level of policymaking did you interact? Local or also national?
How easy/difficult was it to be heard? Did you feel taken seriously by engineers and policymakers?
How much power did you have in your estimation? Did the talks with policymakers have any concrete results?
We know several activists became active in the government: E.g. Steven Schepel (Stop de Kindermoord) told us he became governmental employee. Eisse Kalk (Werkgroep 2000) the same. Do you know more examples like this? How was doing this perceived by the movement? Were these people used as access to the government?

**Other questions**
How do you think the current climate for activism around traffic (safety) compares to that of the 1970s? Would a similar movement be possible today? Is it necessary?
What were the major turning points? How was the political climate in the 1980s different than the 1970s?
Do you know anything about the 1990s until now?
What do you see as the legacy of your work? Was it a success? What still needs to be done?
Appendix B: Interview selection and analysis process

### INTERVIEW SELECTION AND ANALYSIS PROCESS

#### Interview subject selection criteria

- At least a decade of experience in mobility activism or policy in the Netherlands
- Active in the period under consideration (1970-1995)

#### Interview analysis process

1. Interviews were recorded along with detailed time stamped notes
2. Relevant sections were transcribed directly from the interview recordings.
3. Interview notes were coded based on article themes of motivation, actions, institutional relationships, innovations, results, and changes in approach over time.
4. Dutch interviews were translated into English and minor corrections were made for interview subjects who were not native speakers of English.
# Appendix C: List of Interview Subjects

<table>
<thead>
<tr>
<th>Name</th>
<th>Interview Date</th>
<th>Mobility Policy/Activism Role</th>
<th>Years Active in Mobility Policy/Activism</th>
</tr>
</thead>
<tbody>
<tr>
<td>André Pettinga</td>
<td>January 8, 2018</td>
<td>Civil engineer for the city of Delft in the 1970’s where he worked on implementing the woonerf; Worked on cycling in Utrecht from the 1990’s; presently a cycling consultant</td>
<td>1974-present</td>
</tr>
<tr>
<td>Hans van Beek and Leo Hamer</td>
<td>February 5, 2019</td>
<td>Leaders in the Dooiwaar movement in the 1970s to improve livability in The Hague by restricting car traffic and improving conditions for pedestrians and cyclists</td>
<td>1974-1981</td>
</tr>
<tr>
<td>Hugo van der Steenhoven</td>
<td>January 17, 2019</td>
<td>City alderman that developed the first bicycle street in the Netherlands in the 1990s; head of the Dutch Cyclists’ Union from 2003-2012; currently cycling policy consultant.</td>
<td>1994-present</td>
</tr>
<tr>
<td>Jan Ploeger</td>
<td>December 10, 2018</td>
<td>Member of the Dutch Cyclists’ Union since 1975. Worked on the Dutch Bicycle Master Plan in the 90s.</td>
<td>1975-present</td>
</tr>
<tr>
<td>Koos Louwerse</td>
<td>August 12, 2019</td>
<td>Worked on the Dutch Bicycle Master Plan in the 1990s. Currently works as a bicycle policy consultant for cities in Belgium and the Netherlands</td>
<td>1990-present</td>
</tr>
<tr>
<td>Maartje van Putten</td>
<td>June 5, 2020</td>
<td>Founder of Stop the Child Murder in Amsterdam</td>
<td>1974 - 1982</td>
</tr>
<tr>
<td>Peter Plantinga</td>
<td>January 15, 2019</td>
<td>Founding member of Eindhoven chapter of the Cyclists’ Union.</td>
<td>1974 - present</td>
</tr>
<tr>
<td>Steven Schepel</td>
<td>November 13, 2019</td>
<td>Worked on the Woonerf project in Delft in the 1970’s. In 1982, he became chairperson of Stop the Child Murder in Amsterdam and was later responsible for safety at the Ministry of Transport and Public Works. Currently works with MENSenSTRAAT [People and Street]</td>
<td>1970 - present</td>
</tr>
<tr>
<td>Wim Bot</td>
<td>June 9, 2020</td>
<td>Member of the Dutch Cyclist’s Union since 1990. City councilor in Delft from 1994 to 2008. Since 2008, policy advisor and lobbyist for the Dutch Cyclists’ Union.</td>
<td>1990 - present</td>
</tr>
</tbody>
</table>
Chapter 4: The Challenge of the Bicycle Street: Applying collaborative governance processes while protecting user centered innovation

1 INTRODUCTION

This article examines the effect of local collaborative government processes on the implementation of transportation innovations. It does this through a focus on a particular innovation designed to support the growth of cycling as part of a sustainable transportation system: the bicycle street. This simple transportation innovation, in which cyclists have priority over cars on mixed traffic streets, has a stronger local component than many other types of transportation innovations, as cycling is largely governed at the local and regional level (Albert de la Bruhèze & Veraart, 1999; Geels, 2012).

When considering the implementation of a particular innovation, collaborative governance, with its focus on stakeholder engagement (Ansell & Gash, 2008), provides a means to bring both the users and non-users of an innovation into the governance process. Scholars in Science and Technology Studies (STS) argue this inclusion is of fundamental importance because of the key role that users play in shaping technology (Oudshoorn & Pinch, 2003). This is particularly relevant for innovations related to cycling, as actual users and users as mediated through advocacy organizations have shaped local and regional cycling cultures (Oldenziel, Emanuel, Albert de la Bruhèze, & Veraart, 2016) and where the participation from people who cycle is needed to counter the projected users imagined by transportation engineers that often undervalue the needs of people riding bicycles (Oldenziel & Albert de la Bruhèze, 2011).

Cycling innovations are often implemented to promote the broader social goal of moving towards a sustainable transportation system (Krizek, Handy, & Forsyth, 2009; Ogilvie et al., 2011; Song, Preston, & Ogilvie, 2017), and therefore the general theoretical framework of sustainability transitions needs to be considered when examining the most effective ways to develop innovative cycling infrastructure. Specifically, the literature on strategic niche management addresses the challenges of advancing an innovation as part of a sustainability transition (Kemp, Schot, & Hoogma, 1998; Schot & Geels, 2008). Strategic niche management literature describes how an innovation can fail when it requires too large of a deviation from established user practices (Smith & Raven, 2012). This concept has already been applied to transportation policy under the theoretical framework of Strategic policy niche management.

Collaborative governance literature describes how meaningful citizen participation in decision making can lead to successful policy outcomes (Ansell & Gash, 2008; Thomas & Perry, 2006). Strategic niche management literature argues that innovations that require users to make substantial changes in their current practices have an increased risk of failure (Smith & Raven, 2012). When an innovative project is undertaken with a focus on consensus among potentially impacted stakeholders that does not give increased weight to the needs of the users of the innovation, the innovation may develop sufficient support to be implemented, but may not be sufficiently attuned to user practices to meet the needs of its intended user group, creating an obstacle to future upscaling.

The contribution of this paper is thus twofold. First, the article contributes to the scholarship on strategic niche policy management by examining how it functions within the context of collaborative governance. Drawing on case studies that examine the governance processes that led to the implementation of bicycle streets, this article proposes that collaborative processes that focus on consensus can produce unsuccessful outcomes when they involve an innovation in which user practices need to be protected.

Second, it contributes to the debate on transitions to sustainable transportation by articulating the governance issues surrounding the implementation of bicycle streets, an innovative approach to completing cycling networks in order to increase cycling rates. Specifically, the shared space concept of a bicycle street allows it to function as a compromise acceptable to all stakeholders, even though the concessions necessary to implement this compromise have the potential to undermine the functionality of the bicycle street. This article briefly describes the history of the innovation in order to explain the purposes for which it was created and how it is being used in some situations a different purpose: as a tool to resolve disputes over space rather than as a means of providing a low-cost bicycle infrastructure in low traffic areas. It also presents an empirical method for evaluating the degree to which people who cycling are asserting their right of way on a bicycle street, the change in cycling practice that defines the innovation.

The sections that follow accomplish this by providing a brief literature review describing the basic principles of two theoretical frameworks: collaborative governance and strategic niche management. The article then presents a brief outline of the bicycle street’s historical development and implementation in Germany, Belgium, and the Netherlands with a focus on how each country has regulated the bicycle street to ensure that it is used for its intended purpose and implemented it where it can best function. The article then examines the governance processes behind the implementation of one particular bicycle street in Eindhoven, the Netherlands. It describes how a conflict can develop between the goals of collaborative governance and strategic niche management when achieving consensus takes priority over protecting the success of the innovation. Each of these cases show the importance of maintaining the low traffic volumes on bicycle streets and how collaborative
governance processes can make achieving that goal challenging. The discussion section describes the role that enforceable guidelines can play in ensuring the successful implementation of user center innovations such as the bicycle street when collaborative governance processes are involved.

2 METHODS

In examining the literature on bicycle streets, certain elements have received more attention than others. Several authors have addressed the engineering aspects that lead to the development of successful bicycle streets, such as the necessity of design elements that encourage low speeds (Barter, 2009); the management of elements in shared space that create a perception of risk (Clarke, 2006); and elements that impact the effectiveness of bicycle streets such as street widths, parking, traffic volume and speed limits (Pitera & Mateo, 2014; Godefrooij & Hulshof, 2017; Mansvelder, Dijkstra, & Delbressine, 2013). Other studies have looked at the design elements of specific bicycle streets (Andriesse & Ligtermoet, 2005; Andriesse, Rinkel, De Klein, & De Bruin, 2001; CROW-Fietsberaad, 2016) in order to suggest general design guidelines. The relationship between governance processes and the decision to implement a bicycle street, however, is absent from the literature on bicycle streets.

Because the bicycle street is an innovation that has yet to be used on a wide scale (Delbressine, 2013; Fietsberaad Vlaanderen, 2015; Lehner-Lierz, 2002), it can be considered a niche innovation and the approach to upscaling it would be covered under the principles of strategic niche management (Smith & Raven, 2012). The bicycle street is not a type of infrastructure, however, but a set of policies that shape the use of a street; it therefore fits better under the category of strategic niche policy management (Ieromonachou, Potter, & Enoch, 2004). While this framework has been applied to aspects of the implementation of congestion pricing (Ieromonachou, Potter, & Warren, 2006), it has not been applied to the use collaborative governance in the implementation of an innovative policy. This article aims to address the gap in literature on the influence of collaborative governance processes in strategic niche policy management and more specifically to the role of collaborative governance in the implementation of bicycle streets.

In order to accomplish these goals, the article presents an overview of the development of the bicycle street in Germany, Belgium, and The Netherlands, with a specific focus on its original purpose and the regulations developed across the three countries to protect the practices of cyclists. The article then presents an in-depth case study of a bicycle street in Eindhoven, The Netherlands, that reflects the challenges of both achieving consensus among diverse stakeholders and providing the necessary protections for the users of an innovation.

The historical overview of bicycle streets and the description of the governance processes behind the Eindhoven bicycle street rely primarily on archival material. For the Eindhoven case study, this includes reports from the firms hired to manage the project, detailed meeting notes from participatory groups, and newspaper accounts of the project. These archival materials
were supported and put into context through interviews with people knowledgeable with the project and its history: the project leader of the redevelopment, a member of the Eindhoven Cyclists’ Union that worked on the Eindhoven bicycle street, and the former national head of the Netherlands bicycle coalition who, during his time as a city alderman was instrumental in implementing the first bicycle street in the Netherlands. Because the majority of the information acquired during these interviews and used in the article is also supported by publicly available sources, most of the interviews are not directly cited in the article (see Appendix A for a list of the primary sources used in the Eindhoven bicycle street case study).

The evaluation of the bicycle street in the case study is based on both published documents and direct observation. The number of cyclists were counted, and their riding behavior observed at three different locations over six one-hour periods. Additionally, a similar process was repeated for one hour at the location of another bicycle street as a control. The case study section provides a brief description of the process as well as a summary and interpretation of the results (see Appendix C for a complete description of the evaluation process and its results).

3 THEORY

3.1 COLLABORATIVE GOVERNANCE

Collaborative governance structures are becoming an increasingly common part of developing bicycle infrastructure in the Netherlands. Citizen involvement is often a key element in these collaboration agreements. For example, for the development of a bicycle bridge with a project budget of €11 million, the province of North Holland created what it referred to as a public-private neighborhood cooperation. In addition to holding meetings where residents discussed the project, the private company responsible for the design also walked the project site with local residents and incorporated their feedback into the final design. (Ballast Nedam, 2016).

Arguments for the importance of this type of citizen involvement date back to the 1960’s. In 1969, Sherry Arnstein published a model of citizen participation that viewed processes of participation as a means to achieve social reforms and to provide an equitable distribution of government benefits (Arnstein, 1969). Including non-government actors in public sector decision making led to an understanding that more could be achieved through partnering with citizens, community groups and business organizations than could be achieved by a government agency acting independently (Huxham, Vangen, Huxham, & Eden, 2000). This understanding led to the development of collaborative governance processes that tried to address the growing interdependence and uncertainty in policy development in an increasingly complex and diverse stakeholder environment (Booher, 2004).

While collaborative governance can take make forms, one group of scholars has defined it as the processes and structures of public policy decision making and management that engage people constructively across the boundaries of public agencies, levels of government and/or
the public, private and civic spheres in order to carry out a public purpose that could not otherwise be accomplished (Emerson, Nabatchi, & Balogh, 2012, p. 2).

While participatory processes in general have been described as having the potential to improve the legitimacy, social justice, and effectiveness of policy (Fung, 2006), and collaborative governance processes in particular have been developed in order to improve the delivery of public goods (Zadek & Radovich, 2006); extend agency resources (Rogers & Weber, 2010); and develop policies that are more responses to the needs of the citizens affected by them (Newman, Barnes, Sullivan, & Knops, 2004), collaborative governance processes in practice have been subjected to a variety of critiques. This includes the likelihood that future generations and nonhumans will not be adequately represented (O’Neill, 2001) and that power differentials (Davies, 2007; Ghose, 2005) and different ways of knowing (Van Buuren, 2009) can undermine collaborative processes.

This article takes a critical look at collaborative processes in the context of innovation governance, where consensus may be achieved at the cost of the ultimate success of the innovation. In a project that centers on innovation, citizens in their roles as users (and non-users) of the innovation play a crucial role in determining the its form and development trajectory (Hallenbeck, 2012; Kenger & Schot, 2016; Oudshoorn & Pinch, 2003; Schot, Kanger, & Verbong, 2016). The ways in which citizen-user involvement affect the ultimate success or failure of an innovation are absent from collaborative governance literature, and an understanding of them requires understanding the importance of protecting user practices as described in strategic niche management theory.
3.2 The Protection of User Practices in Strategic Niche Management Literature

Transition research examines socio-technical systems, the configuration of elements that allow a specific societal function to be fulfilled (Kenger & Schot, 2016). The social-technical system surrounding the bicycle shares many of the same elements as the automobile (Kenger & Schot, 2016) but these elements are configured quite differently. As a subaltern system (Marletto, 2014), the cultural and symbolic meaning of the bicycle is different from that of the auto, as well as the infrastructure, regulations, policies, and user practices.

Regardless of the particular configuration, strategic niche management literature describes how each of the elements that comprise a socio-technical system have an influence on the adoption of an innovation when it is in the early stages of development (Smith & Raven, 2012). This includes user practices. As stated by Smith and Raven,

Markets and dominant user practices form a selection environment through stabilized market institutions, supply and demand, price mechanisms, user preferences and routines. Path-breaking innovations have a hard time entering the market, for example, ... because they require inconvenient user practices compared to accustomed habits. (Smith & Raven, 2012, p. 1026)

In this context, an innovation will have a greater chance of success if users take action to attempt to adapt the innovations in order to fit with their existing practices and preferences, a response known as fit and conform empowerment (Smith & Raven, 2012). A sustainability transition that focuses on cycling requires attention to processes of adaptation, because the bicycle, with its long history as a means for transportation, touring, and sport, is part of an established system where historically embedded practices are likely to have a strong influence on how users respond to innovations (Shove, 2012).

Strategic niche management literature generally focuses on the innovation trajectory of a particular technology in the context of a sustainability transition (Kemp et al., 1998; Raven, Van Den Bosch, & Weterings, 2010; Schot & Geels, 2008). The principle, however, has been extended beyond new technology and applied to issues of transportation policy under the concept of strategic policy niche management. Strategic policy niche management adopts the same principles as strategic niche management but applies them to policy concepts rather than specific technologies (Ieromonachou, Potter, & Enoch, 2004). The strategic niche policy management framework has previously been used to analyze the implementation of congestion pricing (Ieromonachou, Potter, & Warren, 2006), a policy tool that, like the bicycle street, has been argued to be in support of sustainable transportation goals (Schaller, 2010; Verma, Rahul, & Dixit, 2015).

The brief theoretical overview given above describes collaborative governance and the necessity of protecting the practices required for the use of an innovative technology or policy if the innovation is to succeed. The sections that follow describe the origin and implementation process of bicycle streets in Germany and Belgium, with a specific focus on
how users’ practices were protected and how these processes differed from the implementation of the first bicycle street in the Netherlands. The article then provides a detailed analysis of the implementation of a specific bicycle street in the Netherlands in which collaborative governance processes undermined the user protections suggested as necessary by strategic policy niche management principles. The case study demonstrates that a project can succeed at incorporating citizen input in ways that move the project towards implementation, but the same decisions that increased the support for the project across stakeholder groups before implementation can challenge the long term success of the project and the innovation itself after implementation. The mixed outcome described in the case study reveals the challenge of achieving consensus while protecting the user practices upon which innovations depend.

4 THE ORIGINS AND PURPOSE OF THE BICYCLE STREET IN GERMANY, BELGIUM, AND THE NETHERLANDS

An examination of how and why bicycle streets were introduced in Germany and Belgium helps in clarifying the conditions under which collaborative governance process can undermine the functionality of bicycle streets. Examining the bicycle street in Germany, where it was invented, and Belgium, where it was more recently adopted, shows how these two neighboring countries have both used the bicycle street for more limited purposes than the Netherlands and taken a different approach to its implementation.

The histories of the bicycle street in Germany and Belgium reflect a process of experimenting with a new way to complete bicycle networks where funds for separated infrastructure were not available. This experimentation was followed by the establishment of codified guidelines for a bicycle street, guidelines developed with intention of ensuring bicycle streets served people who cycled by placing restrictions on the autos that used the street.

The first bicycle street in the Netherlands was created for a different purpose. It was not developed due to a lack of funding for bicycle infrastructure but due to a lack of space. The innovation was implemented as a means of managing large amounts of bicycle traffic in places where expanding separated bicycle infrastructure would require politically difficult restrictions on auto parking and auto access. Unlike its neighboring countries, the bicycle street has never been legally codified in the Netherlands.

The following section provides a brief overview of the history of the bicycle street, both in the Netherlands and its neighboring countries, in order to compare and contrast the relationships in each place between the purposes for which the innovation was developed and the ways in which its target user group, cyclists, were supported.
4.1 The German Origins of the Bicycle Street

A bicycle street can be broadly defined as a street that is designed as a bike route but where automobiles and other motorized vehicles are also allowed (Welzen, 2015). The first known implementation of this concept occurred in the German city of Bremen in the early 1980’s. Klaus Hinte, the head of the city’s transportation planning division, was frustrated by the lack of connectivity in the city’s bicycle infrastructure. He was familiar with examples of integrated bike networks in the Dutch cities of Tilburg and The Hague (Lehner-Lierz, 2002). In the late 1970’s, both of these cities had implemented bike infrastructure designed to demonstrate the benefits of separating bicycle and auto traffic and had reconfigured intersections to allow cyclists to cross without having to stop (The Hague Office of Public Works, 1978). Hinte, however, had little hope that Bremen would provide the funding necessary to implement this infrastructure intensive policy and looked for a less expensive solution (Lehner-Lierz, 2002).

As an alternative to the more expensive infrastructure that he saw in the Netherlands, Hinte developed the bicycle street concept in the 1980’s as a way to provide cyclists more direct routes through Bremen’s complicated network of one-way streets. On one-way streets for cars, the entire street became a bike path with bicycles able to travel in both directions. The speed limit for all vehicles was restricted to 10 km/hour. In order to accomplish this within the existing framework of German traffic laws, the first bicycle street required 193 signboards, as every intersection, alley and driveway required a re-statement of the rules for both bicycles and motor vehicles (Lehner-Lierz, 2002).

Because of the legal ambiguity of allowing bicycles to travel in two directions on a street that allowed only one-way auto traffic, the German traffic code was changed on September 1, 1992, to formally allow the construction of bicycle streets. Accompanying the legal status were conditions that a street must meet before it could be designated as a bicycle street. These included the following:

- Bicycles must be the dominant form of traffic or expected to be the dominant form of traffic.
- Bicycle streets must be clearly marked and recognizable as bicycle streets.
- If a street is to be designated as a bicycle street, all other traffic must only be allowed under exceptional circumstances and, when possible, limited to those who live on and around the street.
- Measures must be taken to slow down traffic and allow for cars to park safely.
- The beginning and end of the bicycle street must be marked by design features that provide as little room as possible for cars to enter or exit. These design features could include raised road surfaces or a narrowed road width. This applies to side entrances to the bicycle street as well. (Lehner-Lierz, 2002)

The change in the traffic code provided not only legal status to the bicycle street in Germany but also guidelines for limiting automobiles that ensured that bicycle streets would serve cyclists.
It also provided a set of conditions that contained enough ambiguity to support the arguments of both those in favor of and opposed to a given bicycle street proposal. Possibly for this reason, bicycle streets have not become a common solution in Germany for solving bicycle network connectivity problems (Lehner-Lierz, 2002).

4.2 BICYCLE STREETS IN BELGIUM

The bicycle street came later to Belgium than Germany, but its path from experimental form to legalized section of the traffic code was short and straightforward. In 2011, the city of Ghent implemented the first bicycle street in Belgium. The intention was to improve a section of a main bike route connecting two neighborhoods of the city by using a bicycle street in a location where low levels of traffic made the potentially prohibitive expense of separated infrastructure unnecessary. The implementation of the bicycle street had noticeable and positive results. A comparison of street traffic between 2010 and 2012 showed a doubling in the number of cyclists during the morning rush hour. Auto traffic on the street during that same period dropped by 25% (Het Laatste Nieuws, 2012). In the same year, 2011, a second bicycle street was implemented in Ghent and this street also saw an increase in bicycle traffic and a decrease in auto (Belga News Agency, 2012; Triflex BV, 2013).

Based on the success of these two pilots, Belgium implemented a law in December 2012 that gave the bicycle street a formal place in Belgian traffic code. The Belgian law did not contain the conditional requirements of the German traffic code. Rather, it defined a bicycle street by two simple rules: autos on a bicycle street cannot go faster than 30 km/h and they cannot pass bicycles (Belga News Agency, 2012). The law also designated official signs to mark the beginning and end of the bicycle street (Lemmens, 2012). While no official count exists for the number of bicycle streets currently in Belgium, by 2015 at least six other Belgium cities had adopted the concept (Fietsberaad Vlaanderen, 2015).

The Belgium regulations have the same purpose as the German regulations: supporting a change in cycling practice from biking on the side of the street to biking in the center. They attempt to accomplish this purpose, however, in a very different manner. The German regulations focus primarily on demanding infrastructure elements that will slow down and reduce the number of autos. The Belgian regulations focus on using legal protections to empower cyclists to use the center of the street, but do not regulate the form of the infrastructure itself. As described by Bruno Latour in the essay, “Technology is society made durable,” this ignores the complex interrelationship between material infrastructure and social superstructure (Latour, 1990). The regulations clarify the expected behavior of people who drive on the street, but do not provide any mean for promoting this behavior through infrastructure, design or process elements that would lead to a reduction in the speed or number of autos. The limited protections provided by Belgian regulations, however, are still more expansive than those in the Netherlands, where the traffic regulations provide no protections at all.
4.3 Bicycle Streets in the Netherlands

While the implementation of bicycle streets in Germany and Belgium came from a need for a low-cost solution for connecting segments of the bicycle network, bicycle streets were introduced in the Netherlands for a quite different purpose. When the redesigned Burgemeester Reigerstraat in Utrecht opened again to traffic in 1996, it became the first bicycle street in the Netherlands (De Kruijff, 2017). The street, a section of commercial road on a heavily travelled bicycle route between the city center and Utrecht University, had capacity problems with all of the bicycle, pedestrian, bus and auto traffic on the road. Widening the bike lanes or making the street one way would help, but shop owners were against any solution that limited auto access or removed car parking (Determeijer, 1997). After a series of meetings with those who lived on and near the street, the city made the decision to narrow the lanes of the street and put up a sign that designated the street as bicycle street (Goldenbeld & Van Schagen, 1997). The purpose of the bicycle street, therefore, was to accommodate bicycles in a way that would allow the preservation of auto access rather than limit it.

The bicycle street did not last long, however. Cyclists felt endangered by the large number of cars and buses driving directly behind them (De Kruijff, 2017). Many would reflexively ride on the sides of the street instead of asserting their position in the middle. Trucks in the processes of loading or unloading would block auto traffic. Cyclists would then move to the sidewalk which led to complaints from shop owners on behalf of their customers. After numerous complaints, the police evaluated the situation and believed making the street one way for auto traffic would solve nearly all the issues. This solution, however, was politically unfeasible because shop owners saw this as limiting the number of people who would be able to reach their stores by car, suggesting that the willingness to implement the bicycle street was depended on the retention of auto access in its design. The city tried to address the problems by forbidding cars to pass cyclists and conducting a promotional campaign to encourage cyclists to ride in the center of the road (Determeijer, 1997). These efforts, however, were not sufficient to diminish the complaints, and the bicycle street that cost approximately €300,000 to construct was dismantled just two years after it opened (De Kruijff, 2017).

While the first bicycle street in the Netherlands only lasted two years, the bicycle street concept itself persisted. At the end of 1996, Delft University of Technology published the first design guidelines for bicycle streets in the Netherlands. Rather than using the Utrecht example as a starting point, the study looked at mixed traffic streets in The Hague and Tilburg where high levels of cyclists and low levels of auto traffic gave cyclists the dominant position on the street. While these streets were not designed or labeled as bicycle streets, in practice they served the same function. The report then looked at the history and design of German bicycle streets and identified two key elements that needed to be taken into account in considering the use of the German design in the Netherlands: the Netherlands has a much higher level of cycling than Germany, resulting in changes in how and when autos are able to pass cyclists; and drivers in the Netherlands, according to the report, are less likely to change their behavior.
because of an advisory traffic sign and therefore the bicycle street should only be used in areas where auto traffic can be severely restricted (H. C. Andriesse & Hansen, 1996).

At the time of the report in 1996, at least five Dutch cities were seriously considering implementing bicycle streets in their communities (H. C. Andriesse & Hansen, 1996). In the years since the 1996 report, the number of bicycle streets in the Netherlands has grown dramatically. Research done as part of a master thesis in 2013 estimated that there are now several hundred bicycle streets in the Netherlands. The research also concluded that many cities have no bicycle streets and most people using the Dutch transportation system are not familiar with them (Delbressine, 2013).

Since the first bicycle street arrived in the Netherlands, numerous studies and reports have been published that describe the many different forms that bicycle streets can take and the safety implications of implementing bicycle streets in different contexts. All of the reports share one conclusion: reducing auto traffic improves safety and satisfaction on a bicycle street (Andriesse & Ligtermoet, 2005; Andriesse, Rinkel, De Klein, & De Bruin, 2001; CROW, 2016; Godefrooij & Hulshof, 2017; Mansvelder, Dijkstra, & Delbressine, 2013). The results of these studies, however, are not reflected in the legal definition of a bicycle street. This is because unlike in Germany and Belgium, the bicycle street in the Netherlands has no legal definition. Similar to the Dutch approach to marijuana (Joffe & Yancy, 2004) and prostitution (Bindel & Kelly, 2003), bicycle streets are tolerated, but not strictly legal (Fietsberaad Vlaanderen, 2015).

The regulatory agency that deals with traffic laws in the Netherlands has determined that a street can have signs with the designation “bicycle street” with the understanding that these serve the function of informing road users, not regulating them (CROW-Fietsberaad, 2016). This flexibility in the design and location of bicycle streets allows them to be used for multiple purposes, including the preservation of auto access on streets with high levels of bicycle and auto traffic (Delbressine, 2013).

Allowing individual communities complete influence over the design also means that protections of user practices upon which the innovation depends may be lost in the consensus building process of collaborative governance. The section that follows details the one such collaborative governance process that occurred with the implementation of the Kruisstraat Bicycle Street in Eindhoven. It describes how the city developed this process and how it led to a design that many stakeholders, and particularly those who cycle on the street, came to see as flawed even as they acknowledged that the design had their support at the time of implementation.
5 DEVELOPMENT AND IMPLEMENTATION OF A BICYCLE STREET ON THE KRUISSTRAAT IN EINDHOVEN

5.1 A BRIEF HISTORY OF THE KRUISSTRAAT

The Kruisstraat in Eindhoven first opened as a shopping street in the mid-1950’s (Stichting Eindhoven in Beeld, 2007). Before its redesign, it had a dedicated bicycle lane for those travelling south and mixed bicycle and car traffic for those travelling north (see Figure 1).

Figure 1: On the north end of the Kruisstraat looking south in August 2008 (photo from Google Streetview)

The Kruisstraat is located in the neighborhood of Oud-Woensel (see Figure 2). In 1997, this neighborhood had the highest rates of poverty in the city of Eindhoven and was designated as an area in need of improvement. This resulted in the city council of Eindhoven approving a multi-year renewal plan for the neighborhood in December of 2000. The redesign of the Kruisstraat was a part of this renewal plan (Project Group Oud Woensel, 2008).

In order to realize this renewal, the city of Eindhoven entered into a governance arrangement with the Eindhoven real estate company Domein, the owner of around 400 residences in the Oud-Woensel neighborhood. In 2004, the two parties signed an agreement of intention around the redevelopment concept. Domein would pay the costs surrounding the renewal of its own properties and the development of new property. The city reserved 4.5 million Euros for projects that improved the public space in the neighborhood and also received €817,000 from the Ministry of Housing, Spatial Planning and the Environment to cover the costs of
5.2 REDEVELOPMENT OF THE KRUISSTRAAT

Domein and the city decided that an interactive planning approach was necessary, holding the belief that the most important sources of information about the neighborhood were in the neighborhood itself (Project Group Oud Woensel, 2008).

In order to develop this framework, the two main parties hired the architecture and city planning firm Buro 5 Maastricht to create guidelines for a planning process that would include the active participation of the neighborhood’s residents and business owners (Project Group Oud Woensel, 2008). The process structure ultimately chosen involved the creation of a large
number of participation groups with a particular conceptual theme surrounding each group. Each group had its own process structure and its own leader.

A coordination group made up of members from the professional planning organization, shop owners union, and residents organizations determined what would be covered within each of the sub-groups (RIGO Research en Advies BV, 2011). The coordination group created two different sub-groups to cover the redevelopment of the Kruisstraat: one group discussed quality of life issues on the Kruisstraat and met three times per year; another group discussed the specifics of the redevelopment of the Kruisstraat and met six times per year (RIGO Research en Advies BV, 2011). Being an active participant required attending an evening meeting every month for two years (RIGO Research en Advies BV, 2011). This high level of commitment necessary to participate in the process suggests that the group would be more likely to be comprised with those with a high level of concern about the outcome, rather than a representative sample of the stakeholders effected by the decisions.

The design of the Kruisstraat itself came about after a particularly intensive collaborative process. The first re-design plan for the Kruisstraat was developed entirely by the city, without input from the community. The original plan called for a restoration of part of the original market space as a car free zone and preventing through traffic by cutting off access for automobiles to the arterial road just north of the Kruisstraat (RIGO Research en Advies BV, 2011). While the residents approved of this plan, the business owners strongly objected, believing that the lack of through traffic for automobiles would make their business less visible and less accessible to potential customers (interview with E. Steenkamp, Kruisstraat Redevelopment project manager, on November 9, 2017). The project manager agreed to start the planning process again with meaningful input from the community (RIGO Research en Advies BV, 2011).

In 2009, a community group was formed to provide information and advice about the restructuring of the street. Being a member of the new community group required an even greater level of commitment than one for the original plan, with participants volunteering time on a nearly daily basis (RIGO Research en Advies BV, 2011). The process involved the residential, commercial, and civic organizations active in the neighborhood (City of Eindhoven, 2008) (see Appendix B for a complete list of groups and organizations invited to participate in the Kruisstraat redevelopment).

Following the idea that collaborative governance works to achieve consensus among all involved stakeholders (Ansell & Gash, 2008), the new plan received support from the entire group, with the exception of one business owner (Strik, 2009). The former market on the northern end of the street would remain a parking lot, one way through traffic would be permitted to the northern arterial and two-way traffic into the parking lot, and the Kruisstraat would become a bicycle street (Steenkamp, 2009a) (see Figure 2). In practice, this compromise allowed the Kruisstraat to continue to function as a through route for autos, with a 2015 study that separated origin, destination and through traffic showing an average of 3,500 autos per day using the street, with an average of 300 per day using the street as a through route.
The masterplan allowing this new design was formally adopted by the city on January 28, 2008 (City of Eindhoven, 2008).

5.3 Bicycle Street Implementation, Complaints and Adjustments
The renovated street was opened in two stages, with the northern half completed in July 2011 and the southern section scheduled for completion in November 2011 (Dichtbij, 2011; “Fietser is Koning in Kruisstraat,” 2011). A month after the street opened, the city acknowledged that the street was not functioning as intended and bicycle traffic was not being given priority over motorized traffic on the street (Mobiliteit & RO, 2011). A year after the street opened, a member of the local conservative and suburban-based political party CDA wrote a formal letter to the city requesting the city acknowledge reports of dangerous and hostile encounters between cyclists and motorists on the street and asking for a justification for the street’s unusual design (Weijs, 2012).

In response to the complaints, the city adjusted the street signage and design. It hung banners on both ends of the street in order to inform users that bicycles had priority. Authorities also added large bicycle symbols to the pavement to make clear to cyclists that they should use the center area and not the edges (Mobiliteit & RO, 2011) (see Figure 3).

Figure 3: Bicycle markings on the Kruisstraat pavement (photo taken by the author on September 23, 2019)
While the new bicycle symbols reflected an effort to communicate to cyclists that they should use the center of the road and not the edges, the markings did not solve the safety concerns created by the large amount of auto traffic on the street, parking spots along the length of the bicycle street, and use of the street for the unloading and loading of store trucks, all of which were necessary elements of the compromise over the street design (see Figure 4). Complaints over these elements led to a study of the street by the Eindhoven Police Department and in 2015 they declared the street to be unsafe (Politie Eindhoven, 2015). In response, the police increased enforcement of traffic laws on the street. An enforcement action in 2017 resulted in 17 tickets being written over a 2-hour period, with one driver being measured at 64 km/h (Studio 40, 2017). According to at least one unscientific online poll conducted by a local newspaper, the enforcement actions failed to change user perceptions of the street. In June of 2016, these respondents voted the Kruissstraat the worst street in Eindhoven (De Natris, 2016).

Figure 4: Trucks preparing to unload on the Kruissstraat (photo taken by the author on March 7, 2017)

5.4 EVALUATING HOW CYCLISTS USE THE KRIJSSTRAAT

While police concerns and suggestions of public dissatisfaction may indicate a bicycle street is not functioning effectively, traffic engineers such as Hans Monderman have argued that a certain level of discomfort is necessary in a shared space in order to ensure that those using it pay attention to their surroundings (Clarke, 2006). Reported stress, however, is not the only indication that a bicycle street is not functioning properly, as problems with a bicycle street
can also be evaluated through direct observation. The defining element of a bicycle street is not the color of the pavement or the signs that mark its beginning and end, but rather the manner in which it reverses the traditional yielding relationships between those driving and those cycling: people cycling are expected to maintain their lane position in the center of the road with the cars behind them slowing to the speed of the cyclist. On the Kruisstraat, this idea is conveyed through the symbol of the person on a bicycle in the center of the lane (Figure 3). A street designated as a bicycle street, but in which cyclists ride on the side of the street in order to yield to automobile traffic, is no different, in practice, from a traditional street without bicycle infrastructure.

In order to determine if the Kruisstraat is functioning effectively as a bicycle street, three locations along the street were observed for one hour, with each location being visited two times. At each of these locations, the city had painted an indicator for where cyclists should ride (see Figure 3). The number of cyclists who followed this indicator were counted by observing if they either rode over the image of the cyclist or to its left. Cyclists who rode on the shoulder of the road, intended as a loading area (Dufec, 2015b), or who rode to the far right of the lane (to the right of the image of the cyclist) were also counted.

This process revealed that 79% of people who cycle on the street were riding either on the shoulder or to the far right of the lane. Only 21% rode in the center of the lane in a manner that would result in approaching automobile traffic having to yield to them. The maximum variance for the same road position between any two counts was 10% (see Appendix C for a more detailed description of the process and the data).

A possible explanation for the large number of cyclists not asserting their right of way over people driving could be that most people who cycle have the habit of biking to the far right even if a bicycle street is designed to promote riding in the center of the lane. As a control, therefore, observations were also conducted on another bicycle street in Eindhoven, one with minimal car traffic. On this street, only 9% rode on the far-right side of the lane, with a full 91% riding in the center (see Appendix C for the complete count data).

The safety concerns expressed by the Eindhoven police, the cyclists’ complaints documented in newspaper reports and city meetings, and the quantitative counts showing the frequency of cyclists yielding to cars all suggest that Kruisstraat’s redesign as a bicycle street has not been in service of the stated goal of a bicycle street: improving the cycling network to encourage people to cycle. The discussion section that follows provides possible explanations for why an innovation that requires protections for user practices is not the best choice in collaborative governance processes where stakeholders have opposing goals. It also discusses the potential of regulatory guidelines to ensure these types of innovations are not implemented in situations where user practices cannot be adequately supported.
6 DISCUSSION

The fundamental innovation of a bicycle street is that it changes the established power relationship between automobiles and bicycles. Accomplishing this involves more than simply putting up a sign or changing the color of the pavement. The literature on successful bicycle streets describes the importance of limiting automobile access (Andriesse et al., 2001), removing parking places (CROW-Fietsberaad, 2016), and ensuring that the number of bicycles using the street far outweighs the number of automobiles (Godefrooij & Hulshof, 2017). All of these elements empower the cyclists to maintain their position in defiance of the standard practice of yielding to car traffic. This is key to the success of the innovation. As discussed in strategic niche management literature, the successful adoption of an innovation can be put into jeopardy when the innovation requires a change in existing user practices (Smith & Raven, 2012). If cyclists are not supported in changing their practices and yield to cars on a bicycle street, the innovation has failed, as the bicycle street becomes no different from any ordinary street.

Supporting the necessary change in user practices, therefore, is key to the success of a bicycle street. In Germany, the specific auto restricting elements that support this change have been codified in the regulations governing the establishment of bicycle streets, dictating not only the conditions of implementation, but the specific group that they should serve; the regulations state that bicycles must become the dominant form of traffic (Lehner-Lierz, 2002). In the Netherlands, however, no such regulations exist. With the bicycle street having no specific legal designation in the Netherlands, every community in which it is implemented decides on its own which issues a bicycle street should address and to what degree, or even if, auto traffic should be limited. The lack of legal status means that there is no legal definition of a bicycle street, which allows stakeholder pressure to turn an innovation created to expand the bicycle network for cyclists into an innovation used to maintain access for autos.

Not all bicycle streets in the Netherlands are used to maintain auto access. Successful bicycle streets in residential areas reflect a shared purpose between residents and cyclists (CROW-Fietsberaad, 2016). Restrictions on autos are accepted because fewer cars benefit both groups. Fewer cars create a safer, quieter neighborhood for residents. Fewer cars create a safer, better functioning bicycle street for cyclists. While there may be a degree of negotiation about the precise nature of the auto restrictions, substantially lowering the levels of auto traffic and parking is possible because it is in the interest of all parties involved (CROW-Fietsberaad, 2016).

When a bicycle street is installed in an auto accessible commercial area, however, the key stakeholders may no longer share the same harmony of interests or the same intentions. The Kruisstraat example reflects this. When the bicycle street came up as a suggestion for the commercial area of the Kruisstraat, it was not accepted because of how well it would improve the cycling network of Eindhoven. The bicycle street was suggested after the neighborhood rejected a plan that involved closing off the neighborhood to through traffic and removing parking spaces (Project Group Oud Woensel, 2008). The community recognized that the
situation for cyclists needed to be improved but did not accept the trade-offs in auto access necessary to improve it. The bicycle street here served a different purpose than one in residential areas; it became a tool to preserve auto access rather than a tool to limit auto access and empower cyclists. This is clearly reflected in the terms that were set before the design of the bicycle street was discussed.

The city made a commitment to the neighborhood businesses that not a single parking space would be lost in the redesign process. The city commissioned a study before the project began to count the number of parking spaces in order for this promise to be verifiable (Project Group Oud Woensel, 2008). The bicycle street proposal also involved a removal of the restriction on through traffic present in the original design. While most of the street would become one way for cars, the northern side of the street would remain open for both through traffic and access to the parking lot on the northern end of the street (Deschesne & Bootsma, 2012).

Because a bicycle street allows autos and bicycles to share the same space, it seems like an ideal compromise solution in areas where space concerns do allow separate lanes for bicycles and cars. This compromise only works for people who cycle, however, if they receive enough support to change their practices and maintain their position in front of cars on the street, and this requires limiting auto access rather than preserving it.

Without clear definitions and regulations for what a bicycle street is, collaborative governance processes that involve compromises with shop owners can lead to a loss of the auto restricting elements that make a bicycle street attractive for cyclists. This can be seen as a question of who is perceived as owning the street. Approximately 6,000 cyclists make use of the Kruisstraat every day (Dufec, 2015b). The redesign process for the street, however, was seen as something owned by the neighborhood (RIGO Research en Advies BV, 2011) rather than by the people who use it as part of their cycling route.

When some stakeholders want a bicycle street only because they object to other solutions that are more restrictive for autos, the choice for how to design the bicycle street becomes not one of how to limit auto access the highest degree possible, but rather how much auto traffic and parking can be maintained and still meet minimum safety requirements.

Because bicycle streets have no legal status and no legal requirements, each community must decide on their own what those minimum safety requirements are. The city of Eindhoven looked at other existing bicycle streets in the region, but all of these were bicycle streets in residential areas (interview with E. Steenkamp, Kruisstraat Redevelopment project manager, on November 9, 2017). The first bicycle street in the Netherlands, which failed after experiencing problems similar to those seen on the Kruisstraat, had been dismantled over ten years earlier (De Kruijff, 2017). The use of a bicycle street in a commercial area was also not taken lightly by the shop owners or residents, with the meeting minutes reflecting a clear statement of concern for the risks by those involved (Steenkamp, 2009b). The city and the stakeholders attempted to assess the risk and make choices based on that assessment. With numerous bicycle streets present in the Netherlands and a nearly 20--year history of their use,
however, this risk assessment is still left to individual cities that may have limited local examples of bicycle streets and limited resources to investigate experiences in other cities.

The city’s chose to implement a bicycle street because it had a goal of finding the best possible solution that worked for all stakeholders (RIGO Research en Advies BV, 2011). The national government in the Netherlands has broader goals, which include increasing the number of kilometers cycled nationally by 20% between 2017 and 2027 (CROW, 2020). If some cities implement bicycle streets where they are not well suited and cyclists have a negative experience as a result, this could lead to resistance to bicycle streets in places where they might be well suited to serve cyclists and could help with achieving national cycling goals. While cities may want the flexibility to adapt bicycle streets to the demands of their stakeholders, it is harmful to the users in the specific location of implementation and potential future users in other locations when this flexibility comes at the cost of the user protections necessary for the innovation to be successful.

In the case of the bicycle street, implementing national regulations for restricting auto use could protect the practices of cyclists and prevent the implementation of bicycle streets where they are not appropriate. Just as the German and Belgian regulations addressed concerns specific to the contexts in which their bicycle streets were developed, regulations in the Netherlands should address bicycle streets being used as a means to preserve auto access. These regulations could be as simple as stating that a bicycle street should only be used on streets where low levels of auto traffic make separated infrastructure unnecessary and can only be implemented when all stakeholders agree to limiting auto traffic to the largest degree possible. These regulations would decrease the risk of potentially dangerous bicycle streets being implemented and provide boundaries for its use in the consensus building process, allowing other solutions to be agreed upon when a bicycle street is not the most suitable alternative. While developing uniform design standards that make bicycle streets easily recognizable to all users could provide some support for cyclists’ practices on bicycle streets, changing pavement colors and markings or adding additional signs does not address issues related to traffic volumes, and therefore are not likely to provide adequate protection to cyclists’ practices on bicycle streets that have been implemented in order to maintain auto access.

7 CONCLUSION

This article examined the effect of local collaborative government processes on the implementation of user practice centered transportation innovations through an examination of the bicycle street. It explored the tensions between employing collaborative governance processes and supporting the new user practices necessary for the innovation to succeed.

Collaborative governance literature describes how meaningful citizen participation in decision making can lead to successful policy outcomes (Ansell & Gash, 2008; Thomas & Perry, 2006). Strategic niche management literature argues that innovations that require users to make
substantial changes in their current practices have an increased risk of failure (Smith & Raven, 2012). This article described how the bicycle street, an innovation based on a change in how people who cycle ride on a mixed traffic street, reflects the possibility that a focus on consensus among potentially impacted stakeholders can overshadow consideration for how the users for which it was developed will adapt to it. This may result in the innovation having sufficient support to be implemented without being sufficiently attuned to new user practices, creating a negative experience of the innovation that serve as an obstacle to future upscaling.

The brief outline of the historical development and implementation of bicycle streets in Germany and Belgium showed how both those countries promoted the bicycle street as a means to complete bicycle networks in a cost-effective manner, with efforts to protect the necessary cycling practices codified into law. This stands in contrast to the development of bicycle streets in the Netherlands, where the bicycle street was first used as a tool to accommodate both people who cycled and people who drove in situations where spatial and political constraints limited the possibilities for expanding separated infrastructure. Unlike in Germany and Belgium, the Netherlands has never adopted legally enforceable guidelines for bicycle streets, meaning that the form of each implementation is dependent upon the governance processes that lead to its creation.

The consequences of implementing bicycle streets without any clearly established guidelines was described in the account of the first bicycle street in the Netherlands and in the case of the Kruisstraat Bicycle Street in Eindhoven, the Netherlands. These examples illustrate how the consensus building goals of collaborative governance and can conflict with necessity for properly protecting user practices as described in strategic niche management. Empirical evidence from the Kruisstraat showed that the majority of the people who cycled on the street rode in a manner that allowed autos to have priority, suggesting that user practices were inadequately protected during the collaborative process that led to a consensus on the design of the street. The discussion section described how establishing specific regulations at the national level could provide the necessary protections for user practices in collaborative governance processes, with a specific recommendation of establishing regulations that limit the use of bicycle streets as a compromise tool for retaining auto access in space constrained areas.

Acknowledgments

The authors would like to thank everyone who provided support in the development and revision of this chapter, including Frank Schipper, Ruth Oldenziel, the Sustainable Urban Mobility research team, the members of the Eindhoven Cyclists’ Union, and all of the people who took time out of their busy schedules to discuss the complexities of bicycle streets with me. The author assumes responsibility for all errors.

Funding

This work is part of the VerDuS programme Smart Urban Regions of the Future with project number 438-15-160 which is (co)financed by the Dutch Research Council.
Appendix A: Primary Sources for the Eindhoven Bicycle Street Governance Process

Meeting Minutes and Presentations

Presentation by the Old Woensel Neighborhood Renewal Committee on the Redesign of the Kruistraat/Woensel Market, November 3, 2008

Minutes from the Third Meeting of the Working Group for the Re-design of the Kruistraat/Woensel Market, March 2, 2009

Minutes from the Fourth Meeting of the Working Group for the Re-design of the Kruistraat/Woensel Market, July 13, 2009

Minutes from the Working Group for the Re-design of the Kruistraat/Woensel Market, December 8, 2008

Minutes from the Theme Group meeting for the Re-design of the Kruistraat/Woensel Market, April 20, 2009

Minutes from the Theme Group meeting for the Re-design of the Kruistraat/Woensel Market, May 25, 2009

Responses to submitted questions in advance of the information session on July 22, 2009

Minutes from the Woensel Market Working Group, June 9, 2011

Minutes from the Woensel Market Working Group, April 16, 2012

Minutes from the Woensel Market Working Group, June 17, 2013

Reports

Old Woensel Project Group Redevelopment Master Plan, February 2008

10 Years of Integrated Renewal Planning, Eindhoven: Old Woensel, January 2011

City of Eindhoven Land Use Plan: Oud Woensel, November 2012


Dufec Data Collection and Management, Traffic Research on the Eindhoven Kruisstraat, October 2015

Interviews

P. Plantinga, Eindhoven Cyclists’ Union Representative for the Working Group for the Re-design of the Kruistraat/Woensel Market, interviewed on July 3, 2017

H. van der Steenhoven, former head of the Dutch Cyclists’ Union and City Councilperson during the development of the Burgemeester Reigerstraat Bicycle Street in Utrecht, Interviewed on July 31, 2017

E. Steenkamp, Kruisstraat Redevelopment project manager, interviewed on November 9, 2017
## Appendix B: Community Group Members involved in the original redevelopment plan for the Kruisstraat, from the city of Eindhoven’s “Communication Plan for the Redevelopment of the Kruisstraat and Woenselse Markt,” 2008

<table>
<thead>
<tr>
<th>Dutch Name</th>
<th>English Translation</th>
<th>Represented Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winkeliersvereniging Winkelhart Oud Woensel (WOW)</td>
<td>Old Woensel Commercial Shopping Center Association</td>
<td>Business Owners</td>
</tr>
<tr>
<td>Centrale Vereniging voor Ambulante Handel (CVAH)</td>
<td>Central Association for Mobile Businesses</td>
<td>Operators of stalls at the Woensel Market</td>
</tr>
<tr>
<td>Bewoners(organisatie) Woenselse Markt</td>
<td>Resident Organization Woenselse Markt</td>
<td>Residents of the Woenselse Markt neighborhood</td>
</tr>
<tr>
<td>Bewoners(organisatie) Hemelrijken</td>
<td>Resident Organization Hemelrijken</td>
<td>Residents of the neighborhood Hemelrijken</td>
</tr>
<tr>
<td>Bewoners(organisatie) Kronehoef</td>
<td>Resident Organization Kronehoef</td>
<td>Residents of the neighborhood Kronehoef</td>
</tr>
<tr>
<td>Bewoners(organisatie) Vredesplein e.o.</td>
<td>Resident Organization Vredesplein</td>
<td>Residents of the neighborhood Vredesplein</td>
</tr>
<tr>
<td>Bewoners(organisatie) Bakkerstraat</td>
<td>Resident Organization Bakkerstraat</td>
<td>Residents of Bakker Street</td>
</tr>
<tr>
<td>Vereniging Oud Woensel</td>
<td>Oud Woensel Association</td>
<td>Social club for the Old-Woensel neighborhood</td>
</tr>
<tr>
<td>Initiatiefgroep Nieuw Oud Woensel (NOW)</td>
<td>Action Group New Oud Woensel</td>
<td>Resident organization in the Oud Woensel neighborhood formed in response to the renewal plans</td>
</tr>
<tr>
<td>Eindhoven Politie</td>
<td>Eindhoven Police</td>
<td>Eindhoven police</td>
</tr>
<tr>
<td>Eindhoven Fietsersbond</td>
<td>Eindhoven Cyclists’ Union</td>
<td>People who cycle in Eindhoven</td>
</tr>
<tr>
<td>Platform Gehandicapten Eindhoven</td>
<td>Eindhoven Platform for People with Disabilities</td>
<td>People in Eindhoven with disabilities</td>
</tr>
<tr>
<td>Gemeente Eindhoven</td>
<td>The City of Eindhoven</td>
<td>The City of Eindhoven</td>
</tr>
</tbody>
</table>
Appendix C: Eindhoven bicycle streets evaluation process and results

Six one-hour observation periods were used to determine if people riding bicycles on the Kruisstraat bicycle street were asserting their priority on the street and treating cars as guests. In three locations along the street, the city painted an outline of a person riding a bicycle in the center of the lane in both directions in order to indicate where cyclists should be riding. The number of cyclists who either rode over part of the image of the cyclists or to the left of this image were counted. Cyclists who rode in the shoulder of the road – intended as a loading area – or who rode on the very edge of the street, to the right of the image of the cyclists, were also counted. The shoulder extends 103 cm from the curb, the image of the cyclists begins 59 cm from the shoulder, and the remainder of the lane is 133 cm. The observations, therefore, counted the number of cyclists either riding in the shoulder, riding on the right 1/3 of the lane (edge), or riding in the left 2/3 of the lane (center) for both southbound (S) and northbound (N) traffic. The three columns on the right show the percentage of cyclists in each location as a combined total of north and southbound bicycle traffic.

As a control, observations were also conducted on another bicycle street in Eindhoven. Because this bicycle street has no shoulder, these columns are blank. The edge measurement remained 59 cm with the remainder of the lane totaling 292 cm.

Table A.1: Date, time, location and position information for the bicycle street counts

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Location</th>
<th>S Shoulder</th>
<th>S Edge</th>
<th>S Center</th>
<th>N Shoulder</th>
<th>N Edge</th>
<th>N Center</th>
<th>Center</th>
<th>Edge</th>
<th>Shoulder</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-7-2019</td>
<td>17:00 - 18:00</td>
<td>18 Woenselstraat Markt</td>
<td>79</td>
<td>148</td>
<td>90</td>
<td>91</td>
<td>195</td>
<td>91</td>
<td>20,51%</td>
<td>54,58%</td>
<td>24,92%</td>
</tr>
<tr>
<td>17-7-2019</td>
<td>17:00 - 18:00</td>
<td>78 Kruisstraat</td>
<td>87</td>
<td>211</td>
<td>83</td>
<td>84</td>
<td>286</td>
<td>96</td>
<td>18,19%</td>
<td>56,72%</td>
<td>25,09%</td>
</tr>
<tr>
<td>18-7-2019</td>
<td>17:00 - 18:00</td>
<td>144 Kruisstraat</td>
<td>135</td>
<td>181</td>
<td>27</td>
<td>109</td>
<td>267</td>
<td>100</td>
<td>16,61%</td>
<td>54,70%</td>
<td>28,69%</td>
</tr>
<tr>
<td>10-10-2019</td>
<td>17:00 - 18:00</td>
<td>18 Woenselstraat Markt</td>
<td>76</td>
<td>188</td>
<td>82</td>
<td>173</td>
<td>225</td>
<td>69</td>
<td>28,56%</td>
<td>50,96%</td>
<td>20,48%</td>
</tr>
<tr>
<td>9-10-2019</td>
<td>17:00 - 18:00</td>
<td>78 Kruisstraat</td>
<td>119</td>
<td>212</td>
<td>48</td>
<td>133</td>
<td>299</td>
<td>87</td>
<td>20,16%</td>
<td>56,90%</td>
<td>22,94%</td>
</tr>
<tr>
<td>17-10-2019</td>
<td>17:00 - 18:00</td>
<td>144 Kruisstraat</td>
<td>108</td>
<td>177</td>
<td>29</td>
<td>156</td>
<td>235</td>
<td>83</td>
<td>23,48%</td>
<td>52,28%</td>
<td>24,24%</td>
</tr>
<tr>
<td>23-9-2019</td>
<td>17:00 - 18:00</td>
<td>80 Leenderweg</td>
<td>2</td>
<td>5</td>
<td>130</td>
<td>11</td>
<td></td>
<td></td>
<td>91,22%</td>
<td>8,78%</td>
<td></td>
</tr>
</tbody>
</table>
Chapter 5: Towards a Maintenance-Based Approach to Mode Shift: Comparing two cases of Dutch cycling policy using social practice theory

1 INTRODUCTION

The transition to sustainable transportation systems has become an important element of long-term transportation planning (Bertolini, Clerq, & Straatemeier, 2008; Miller, de Barros, Kattan, & Wirasinghe, 2016; Schiller & Kenworthy, 2017). The policies behind this goal often focus on investing in programs intended to change people’s attitudes towards sustainable transportation with the belief that this will lead people to drive less and use sustainable modes of transportation more (Domarchi, Tudela, & González, 2008; Kormos, Gifford, & Brown, 2015; Stradling, Meadows & Beatty, 2000; Vredin Johansson, Heldt, & Johansson, 2006; Young & Caisey, 2010).

This approach has been criticized by scholars using social practice theory (SPT) (Shove, 2010; Strengers & Maller, 2015). SPT posits that practices are complex and that more than a change in attitude is necessary to alter them (Evans, 2012). Scholars that acknowledge this complexity have argued that change can be achieved through more comprehensive policies that support all the different elements of a practice: materials, meanings and competencies (Evans, 2012; Spotswood, Chatterton, Tapp, & Williams, 2015; Watson, 2012). This, however, is still difficult, as practices are interlinked, which makes them very hard to change. For example, many people who drive have multiple appointments scheduled close together. They may develop a positive attitude about alternative forms of transportation as well as relevant skills (‘meaning’ and ‘competencies’ in the language of SPT), but actually using them would require making difficult adjustments to other activities such as shopping, childcare, social activities, etc. (Berg & Ihlström, 2019; Jeekel, 2011).

Previous studies that applied SPT to sustainability transitions have focused exclusively on cases where the goal is to replace a less sustainable practice with a more sustainable one (Cass & Faulconbridge, 2016; Hargreaves, 2011; Sahakian & Wilhite, 2014; Verbeek & Mommaas, 2008; Watson, 2012); in the field of transportation, that has often translated into focusing on how driving can be substituted by cycling (Bjørnarå et al., 2019; Dill & Carr, 2003; Rowangould & Tayarani, 2016). Our proposition is to use SPT to focus on the possibilities for maintaining sustainable practices and thus reducing the number of people that change from a sustainable

practice to a less sustainable one. This means articulating a new approach for achieving a mode shift for sustainability purposes, an approach that could compliment the current change-based efforts. This shift would occur by reducing the number of people that changed from cycling to driving, for instance as the result of a life event such as a new job, marriage, the birth of a child, or retirement or due to a deterioration of cycling conditions.

The application of this approach might not only bring about an increase in the percentage of people cycling, it would also allow for investments to support existing, desired sustainable practices, ensuring that they are not lost. The alternative approach of only investing in people not currently engaged in a particular behavior means, by definition, not investing in the people who already practice the desired behavior. This approach seems to assume that the existing practices are not vulnerable to change. Yet they are, as, for example, research on the decline of cycling in Europe (Oldenziel et al., 2016) or substitution of walking and using public transit with ride-hailing in the US demonstrates (Clelowl & Mishra, 2017). Our proposed approach to mode shift focusing on maintenance of sustainable mobility practices puts this vulnerability and possibility of change at the center of planning sustainable transitions. As the concepts of recruitment and defection are well established elements of SPT (Herington et al., 2017; Shove et al., 2012; Strengers and Maller, 2014; Watson, 2012), using the theory to argue for a focus on the maintenance of existing practices does not require further expanding or developing SPT, but rather giving attention to already present but overlooked elements of the theory as they relate to sustainable transportation goals.

To support our argument, we use the case of cycling in the Netherlands. With over a quarter of all trips made by bicycle, the Netherlands has the highest rate of cycling in the world (Harms & Kansen, 2018). The cycling rates across different ages, however, are not evenly distributed. Children, teenagers, and young adults cycle at much higher rates than middle-aged and older adults, with teenagers between the age of 12 and 19 biking an average of 2,000 km a year, double the average of adults in the Netherlands (Centraal Bureau voor de Statistiek, 2015). Thus, in this case most people engage in a sustainable practice from a young age but many move to the less sustainable practice of driving at a later age. If more people maintain their cycling practices instead of changing to driving practices, the ratio of driving to cycling will shift in favor of cycling.

Drawing on two national Dutch cycling policy programs that illustrate two different possible approaches to a mode shift in favor of cycling, we argue that investments in a maintenance-based approach also have the potential to contribute to achieving the modal split goals seen in change-based approaches. Specifically, we compare the Bicycle Master Plan, a comprehensive national investment in cycling promotion that took in place in the Netherlands from 1991 to 1997, and With the Bicycle Less Congestion, a Dutch national program to develop bicycle highways near congested roads that lasted from 2006 to 2009.

While the first program, the Bicycle Master Plan, took a broad approach and considered any element that would improve the chance of increasing cycling rates over the long term, With the Bicycle Less Congestion invested all of its resources in a very specific approach: promoting a shift from driving to cycling by targeting people driving on congestion prone routes and
investing in changes that might encourage them to change their behavior and choose to cycle instead.

The contribution of this paper is thus twofold. First, we contribute to the scholarship on sustainability and behavior change that uses SPT with the goal of advising policymakers. Drawing on the strengths of SPT postulates, we propose that the implications of focusing on the maintenance of sustainable practices has thus far not received attention. This maintenance-based approach could apply to any situation in which a large number of people have a sustainable practice but might change to an unsustainable practice (areas with high levels of cycle or transit ridership, for example).

Second, we contribute to the debate on transitions to sustainable transportation by articulating a new approach to achieving mode shift, providing a broader understanding of the policy options available. We do not suggest that no investments should be made in encouraging people to move from driving to cycling; rather, we argue that the maintenance of sustainable transportation practices represents an approach missing from the policy toolkit that could complement and support current investments.

In the sections that follow, we will describe how social practice theory has been applied to sustainability transitions, with a specific focus on cycling. We will give a brief overview of the two Dutch national cycling policies that we will be using as case studies to illustrate our argument. We will then discuss the two policies in relation to social practice theory to show how the two policies reflect two different approaches to mode shift, one based on maintenance and the other on change. Finally, we will conclude with a discussion section that relates some of the limitations of our approach as well as the potential implications and applications of our findings.

2 RESEARCH DESIGN AND METHODOLOGY

Our article compares With the Bicycle Less Congestion with the Bicycle Master Plan. Rather than evaluating these two cycling policies based solely on outcomes, we analyze both policies through the lens of SPT and compare them to illustrate an approach to mode shift that is supported by existing SPT concepts but has not received attention in the literature that applies SPT to the transition to sustainable transportation systems.

The analysis is based on government documents, consultant reports, and contemporaneous statements from project supporters and detractors. The majority of these documents are in the Dutch language. For the Bicycle Master Plan, this includes three comprehensive reports produced by the Ministry of Transport, Public Works and Water Management: one states the policy of the Bicycle Master, the second evaluates the program, and the third documents what had been accomplished after its conclusion. The analysis of With the Bicycle Less Congestion is based on a government commissioned study conducted by a transportation consulting company that sought to predict the effects of the program, as well as supporting material from project partners that detailed goals, budgets, and implementation plans. We have also
gathered and used critiques and commentary on the projects that have been published in Dutch language journals. The references lists the original Dutch names of all the documents consulted along with English translations.

3 SOCIAL PRACTICE THEORY AND TRANSITIONS TO SUSTAINABLE TRANSPORTATION

3.1 SOCIAL PRACTICE THEORY ON BEHAVIOR CHANGE

A transition to sustainable forms of transportation requires changes in people’s travel behavior. Over the past two decades, several systematic reviews have been conducted on the effectiveness of various interventions intended to encourage people to switch from driving to more sustainable forms of transportation such as walking or driving (Ogilvie et al., 2004; Pucher et al., 2010; Scheepers et al., 2014; Yang et al., 2010). New approaches have also been articulated, including life-oriented travel behavior research that looks at the long-term interdependency of life choices and transportation choices (Zhang and Van Acker, 2017) and mobility management campaigns that can include a broad array of approaches from congestion charges to providing personal assistance in the development of individual travel plans (Hiselius and Rosqvist, 2016).

The major contribution of social practice theory (SPT) to this debate on behavior change and transitions to sustainability has been in proposing an alternative to the so-called “ABC framework” of social change as Shove (2010) has labeled it, with ABC standing for attitude, behavior and choice. As summarized by Shove (2010), the ABC framework, based on theories of planned behavior, assumes that social change depends on promoting attitudes that will lead to a set of desired behaviors that an individual will choose so long as key barriers are removed. SPT offers a critique of this behavior change model, arguing that instead of focusing on individual behavior and individual action, transitions to sustainability require focusing on socially shared practices defined as

a routinized type of behavior which consists of several elements, interconnected to one other: forms of bodily activities, forms of mental activities, ‘things’ and their use, a background knowledge in the form of understanding, know-how, states of emotion and motivational knowledge. (Reckwitz, 2002, p.249, as cited in Strengers and Maller, 2015)

While the debate over how to conceive of these particular elements of social practice continues, many scholars use the framework developed by Shove, Pantzar, and Watson (2012) that describes three primary elements that constitute a practice: meanings (ideas, aspirations, values and symbolic interpretations); competences (shared abilities and practical knowledge); and materials (physical things, including technologies, objects and infrastructure) (Strengers & Maller, 2015). These concepts become the foundation for understanding the dynamics of
social practices, including their development and change over time (Reckwitz, 2002; Shove & Pantzar, 2007; Shove et al., 2012). In particular, the complexity of practices as comprised of meanings, materials and competencies, means that more than a change in attitude is necessary to alter them (Evans, 2012; Genus & Jensen, 2019, Shove, 2010). Accordingly, SPT scholars suggest that the most effective focus for a policy oriented towards behavior change is an examination of “the social and collective organization of practices – broad cultural entities that shape individual’s perceptions, interpretations and actions within the world” (Hargreaves, 2011, p. 79).

Taking cycling as an example, this means that understanding the practices of cycling requires an understanding of the “actions, habits and routines of daily experience” (Watson, 2012, p. 490) of those who cycle. It also requires an understanding of the material elements involved with the practice, including bicycle paths, bicycle repair shops, and the bicycle itself, among others. These elements of meanings, materials, and competencies are certainly not identical for each individual cyclist but have wide differences across time and location and can even vary between specific instances of cycling by a single individual. Taken collectively, however, a diverse set of performances of cycling can reveal patterns that provide insights into the practice of cycling and how that practice may be likely to change (Watson, 2012).

According to SPT, a social practice grows when more people are recruited into it than defect from it and declines when more defections occur than recruitments (Shove et al., 2012). This process of defection has received limited attention in studies of mode shift by SPT scholars, as we will discuss in the next section. For our argument, however, this process becomes central as we propose to shift the focus from change to maintenance in the debate on sustainable transitions and modal shift.

3.2 Social Practice Theory, Sustainability Transitions and Cycling

Cycling policy and practice and in the context of transitions to sustainable mobility has been a subject of analysis for a number of SPT scholars. In applying SPT to developing policies designed to increase cycling rates, previous research shares a common approach: examining the meanings, materials, and competencies of the people engaged in the practice of cycling to understand which interventions will be the most effective. Rather than starting with traffic counts or engineering principles, the literature that applies SPT to cycling begins with a statement of the need to understand the performance of cycling as an embodied practice of the people who engage in it. In this paper we draw on the major insights from this literature, yet propose a novel approach that addresses the gaps in the debate. This section provides a brief overview of research that has explicitly addressed the relevance of social practice theory to encouraging cycling as a form of sustainable transportation and describes the connections between their work and our central argument.

Watson (2012) has linked SPT with cycling in order to provide an overview of the types of interventions that support a transition to sustainable transportation systems. Watson frames the rise of the automobile and the decline of cycling as a process of recruitment and defection,
with the two modes competing over the same limited resources of time, space and money. Watson (2012) is not arguing that declines in cycling are solely responsible for the rise of automobility, but rather argues that understanding transport as an interconnected system involving bundles of practice allows for points of intervention to be identified that can increase recruitment towards more sustainable forms of transport. We build on this argument, but, unlike Watson (2012), we focus specifically on how the retention or maintenance of cycling practices can create a mode shift in favor of sustainable transportation.

Shove (2012) does focus on retention, yet she focuses on a context where cycling is marginal. She examines the way that cycling challenges the traditional narrative of innovation by being a transportation technology that many predicted would disappear and yet endures through the practices of cyclists in areas that terms “pockets of persistence” – countries and cities where cycling is no longer practiced by the majority of people but still survives as an active practice among a subset of the population (p. 372). We build on this concept by describing how a transition to a sustainable transportation system can be achieved in a country where cycling is still practiced by the majority of people.

Spotswood et al. (2015) directly employ SPT as a tool for exploring ways to increase cycling rates in the United Kingdom. Noting that the cycling rate has held steady at 2% in the United Kingdom in spite of a large amount of money invested in programs targeting voluntary behavior change at an individual level, they suggest the use of SPT as an alternative approach for both understanding and potentially creating social change. The authors examine not only how the individual components of practices reveal barriers to cycling, but also how these components both have direct connections with each other and are interlinked with the practice of driving: thus, for instance, reducing auto speed limits changes the efficiency meanings attached to driving while increasing the sense of competency for people on bicycles afraid of fast-moving traffic. The authors suggest “a range of coordinated legislation, infrastructure, policy and marketing interventions may be required for reconfiguration of utility cycling practice” (Spotswood et al. 2015, p.30) and that employing SPT approach to analyze current cycling practices could help “intervention managers to produce a complex but rigorous web of interrelating factors which can form the basis for a multi-layered behavior change strategy” (ibid). The conclusions are drawn from two studies conducted in the UK, a country with currently low average cycling rates. Our paper draws directly on these conclusions, but applies them to a country with high cycling rates where the practice of cycling may need to be supported but not necessarily reconfigured.

Finally, Larsen (2017) has used SPT to examine a city with high cycling rates in detail, describing the materials, meanings, and competencies that allow cycling practices in Copenhagen to thrive. The article focuses on the complex relationship between existing user practices and the steps taken by planners in the city to recruit people into the regular performance of cycling practices. We examine a country with high levels of cycling and describe the interaction between planners and cyclists across two different policies, but we place our focus on avoiding the defection of existing practitioners rather than on the recruitment of new practitioners.
4 TWO DUTCH NATIONAL BICYCLE POLICIES: AN OVERVIEW

In this section we discuss two specific Dutch national programs in the domain of cycling to demonstrate, how a focus on maintaining existing cycling practices can help achieve transportation sustainability goals. The first, the Bicycle Master Plan (‘Masterplan Fiets’ in Dutch) was a 32.6-million-guilder (approximately 14.8 million Euros) project implemented over seven years in the 1990’s to reduce the projected growth in car traffic (Directoraat-generaal Personenvervoer, 1998). The second, With the Bicycle Less Congestion (‘Met de Fiets Minder File’ in Dutch) had a budget of 31 million Euros over three project stages and was started in 2006 as part of a larger set of congestion reduction strategies (Van Boggelen, 2010). Both plans were funded and administered at the national level (Directorate-General for Passenger Transport, 1999; Van Boggelen, 2010). Because bicycle planning in the Netherlands moved largely to the provincial and local level after the Bicycle Master Plan (Ministry of Transport Public Works and Water and Management, 1992), these two projects both reflect what were viewed as national priorities in cycling policy at the time of their development. Comparing them reveals changes in how the national government approaches cycling policy. While these programs had very similar goals, they developed through different processes and measured their success in different ways. The following section provides an overview of the purpose, development, and implementation of each program (for a summary of the key elements of each program, see Table 1). [Table 1 near here]

4.1 THE BICYCLE MASTER PLAN

4.1.1 Project Background

In 1996, a planned decentralization process began throughout the Dutch government, and one result of this was that provinces and regional entities became responsible for how money would be allocated to bicycle projects (Directoraat-generaal Personenvervoer, 1997). In September of 1990, in anticipation of this decentralization process, the national government of the Netherlands, under the authority of the Ministry of Traffic and Water Management, formed a project group called Bicycle Master Plan (Directoraat-generaal Personenvervoer, 1997). The purpose of this group was to encourage provincial and local governments, businesses and institutions, public transportation companies, and national ministries to integrate cycling policies into their plans and programs. (Directoraat-generaal Personenvervoer, 1997). More specifically, the project group wanted to make sure that cycling policy, even after it was decentralized, would still receive sufficient attention at other levels of government to make a significant contribution to the goal that the government set in 1986 to reduce the projected growth in car traffic by 50% (Ministry of Transport Public Works and Water and Management, 1992). The Bicycle Master Plan lasted from 1991 to 1997 and during those six years implemented 112 separate bicycle projects (Directoraat-generaal Personenvervoer, 1997).
4.1.2 Project Structure
The structure of the Bicycle Master Plan was relatively simple. The project was directed by a project leader who oversaw the work of a project group. The project group consisted of people with an experience in policy formation from a variety of different departments within the Ministry of Traffic and Water Management. While the ministry was ultimately responsible for determining which projects to implement, they also relied on feedback from a much larger committee made up of members of a wide variety of bicycle interest groups. This committee consisted of representatives from 13 different organizations. [Table 2 near here]

These different organizations were particularly active in the early years of the project, providing advice on how the policies and projects formulated by the ministry could obtain the broadest level of support possible (Directoraat-generaal Personenvervoer, 1997).

4.1.3 Project Goals
The initial policy document for the Bicycle Master Plan stated the following as the central goal of the project: “Promote the use of the bicycle while simultaneously increasing the safety and attractiveness of that bicycle use” (Directoraat-generaal Personenvervoer, 1998, p. 15). This single sentence demonstrates a commitment to both new and current users of the cycling system and is stated broadly enough to allow for a wide variety of projects under the policy.

This potential for project diversity was realized in the 112 projects that were ultimately implemented under the Bicycle Master Plan. These projects were broadly categorized as 31 research projects, 41 pilot and model projects, 18 projects related to policy development and 22 information exchange projects (Directorate-General for Passenger Transport, 1999). These projects formed the means by which the policy planned to achieve its stated goal of a 30% increase in kilometers travelled by bicycle between 1986 and 2010 (Directoraat-generaal Personenvervoer, 1997).

4.1.4 Evaluation
The Bicycle Master Plan project group was formed in 1990 with a goal of completing all of the proposed projects by the end of 1994. The project was ultimately extended until 1996 with the focus in the final year of evaluating the results and communicating them with all of the stakeholders involved (Directorate-General for Passenger Transport, 1997). Both the long-term nature of the plan and the diversity of the projects that came under it make providing a simple evaluation of its outcomes difficult. The final report detailing the results listed both the gains that had been made through the project, including the development of new best practice concepts through the research and the successful implementation of approximately half of the pilot projects, and the challenges that still remained, including the integration of bicycle policy with long term city planning goals, the incorporation of bicycle parking with new and existing buildings, and the optimization of public transport and cycling, including improved bicycle parking at bus stops [see figure 1] (Directorate-General for Passenger Transport, 1999). Throughout the period of the Bicycle Master Plan, cycling rates in the Netherlands remained relatively stable, with the average Dutch adult cycling approximately 2 km per day in both 1990 and 1996 (Godefrooij and Goeverden, 2010).
Although cycling rates in this period did not rise substantially, the evaluation produced at the end of Bicycle Master Plan concluded that the project had had a measurable effect on the support Dutch cities provided to cyclists. A consulting group selected 19 Dutch cities of varying size across the Netherlands and reviewed their approach to promoting bicycle use before and after the Bicycle Master Plan. The review found that 16 of the 19 cities were now putting more of a focus cycling policy, including ensuring integrated cycle path networks and developing plans to actively encourage cycling. None of the cities had reduced the amount of attention they gave to cycling (Directoraat-generaal Personenvervoer, 1998).

**4.2 WITH THE BICYCLE LESS CONGESTION**

**4.2.1 Project Background**

In 2006, the Dutch national government took on a new role in the funding and development of bicycle infrastructure when the Ministry of Traffic and Water Management began the program Congestion Proof (Fileproof in Dutch). The program was created to develop a series of measures that could potentially reduce congestion within a relatively short period of time. The ideas came from government workers, organizational and societal partners of the government, and 16,000 suggestions sent in from readers to the Dutch newspaper *De Telegraaf*. Ultimately, between its inception in 2006 and its conclusion at the beginning of 2009, Congestion Proof implemented 40 different programs intended to reduce congestion (Eurlings, 2009).
One of these programs was With the Bicycle Less Congestion. Developed in cooperation with the Dutch Cyclists’ Union, the program focused on developing and improving bicycle routes parallel to highways in order to increase the number of people choosing to bicycle for trips between 5 and 20 kilometers. (Van Boggelen, 2010).

4.2.2 Project Structure
The project began in 2006 with the ministry and the Dutch Cyclists’ Union selecting five city pairs where the routes between the cities had a high level of congestion. The government then invested in improving these routes for cyclists, building new bike lanes and improving existing ones as well as improving wayfinding signage and reducing spillover traffic from the highway along the bike routes [see Figure 2] (“Over Fiets filevrij,” 2017).

Fig. 2. This high-speed cycling route between Utrecht and Breukelen was one of the five routes constructed under With the Bicycle Less Congestion. Photo by Henk-Jan Dekker; used with permission.

4.2.3 Project Goal
With the Bicycle Less Congestion had a specific policy objective. The goal was to bring about a 5% reduction in highway congestion by improving the bicycle infrastructure near congested areas. The project leaders initially identified five routes with a high potential of commuter trips under 15 km. The congestion reduction could be achieved by convincing people who drove on these routes to bike instead, potentially reducing congestion in the process (Muconsult, B.V., 2007)
4.2.4 Evaluation of With the Bicycle Less Congestion
In 2008, the project changed its name to Bicycle Free from Congestion (‘Fiets filevrij’ in Dutch) (Van Boggelen, 2010). Under this name, the group evolved from developing its own projects to providing project support when funding became available for new cycling highways (“Over Fiets filevrij,” 2017). For example, in 2016 the Bicycle Free from Congestion platform worked with the Ministry of Infrastructure and Water Management to organize discussion sessions with local and regional groups working on cycle highways. The discovered that a majority of the participants found financing to be a major obstacle in implementing their bicycle highway plans (Bot et al., 2016). In 2018, the Ministry of Infrastructure and Water Management dedicated an additional 100 million Euros to support bicycle highway and station bicycle parking projects (Rijksoverheid, 2018a).

Two years after the inception of With the Bicycle Less Congestion, an initial evaluation determined that the new infrastructure resulted in 1% of the drivers along the congested route switching to cycling, much lower than the target goal of 5% (the calculation of this 1% mode switch has been challenged based on its low sample size). Even accepting the 1% change in practices, the effect on congestion reduction was so low as to be within the margin of error (Van Boggelen, 2010). Cycling levels on a whole did rise during the period of With the Bicycle Less Congestion, but they continued along a trend of gradually increasing cycling rates in the Netherlands, with the average percentage of short distance trips (up to 7.5 km) taken by bicycle having risen from 31% to 34% between 2000 and 2016 (Rijksoverheid, 2018b).

5 COMPARATIVE ANALYSIS OF THE BICYCLE MASTER PLAN AND WITH THE BICYCLE LESS CONGESTION
While the Bicycle Master Plan took a broad approach and considered any element that would increase the chance of increasing cycling rates over the long term, With the Bicycle Less Congestion invested all of its resources in a very specific approach. It has promoted a shift from driving to cycling by targeting people driving on congestion prone routes and investing in changes that might encourage them to change their behavior and choose to cycle instead. The difference between the Bicycle Master Plan and With the Bicycle Less Congestion does not simply represent a difference in focus, however. Interpreting the policies through the lens of social practice reveals key differences between an approach focused exclusively on change and one that includes the maintenance of existing practices and demonstrates the potential value of the latter. This section discusses differences in how each program considered the practice of cycling in terms of materials, meanings, and infrastructure; how those differences led to differing formulations of project goals; and how those goals reflect a fundamentally different approach to mode shift.
5.1 Differences in Developing an Understanding of the Elements of Cycling Practice

Given that an understanding of the complexity of practices and the diverse elements that comprise them is at the core of SPT, any policy focused on behavior change would have to have a means of acquiring knowledge about this diversity in order to be effective. This attempt to understand the practice of cycling in all its diversity is well reflected in the Bicycle Master Plan. The governance structure of the Bicycle Master Plan that provided advice and consultation on the proposed projects involved 13 different organizations, each representing aspects of the meanings, materials or competencies associated with cycling (see Table 1). For example, the material elements of cycling were represented not only by the government agencies that would fund the infrastructure, but also by interest groups representing the business that sold bicycles, repaired bicycles, and provided bicycle parking. Each of these groups would be likely to have insights into the competencies of their clients and how particular investments could support the practices that sustained their businesses. Similarly, people who cycle were not represented by only one advocacy group, but rather four different cycling advocacy groups, allowing for a diversity of perspectives from cyclists through a diverse set of representation on which meanings, materials and competencies associated with cycling deserved attention.

While the Bicycle Master Plan attempted to increase cycling rates by spreading its investments throughout a wide range of projects that intersected with a broad array of elements from the cycling system, the infrastructure developed by the With the Bicycle Less Congestion did not reflect this same degree of complexity in developing an understanding of the practice of cycling. With the Bicycle Less Congestion isolated a single element, the state of bicycle infrastructure near congested highways, and relied on this as its only mechanism for achieving its modal change goal. The focus on a limited group, people who drive on congested roads, seems to have carried over into the resulting infrastructure design: straight, wide bike paths built adjacent to highways. This design reflects the principles that make automobile infrastructure effective, not cycling, as cycling rates correlate with fine grained networks of cycling infrastructure (Marshall & Garrick, 2010). Even if people who drive find the bicycle highway attractive, the policy does not address the cycling experience leading to and from the bicycle highway. It also does not take into account the particular needs of existing cyclists, as will be discussed in detail in section 4.3. The infrastructure is built around the requirements for cycling perceived to be held by people who drive but the policy does not address the bundles and complexes of linked trips made by those who drive that result in car dependency (Shove et al., 2015). While the Netherlands is a country of relatively high density, it has been a part of this global trend of increased individual commitments distributed over a wide area but scheduled close together. Schedules that are compressed in time and spread out over space limit people’s ability to shift the mode of a single trip type, such as the commute from home to work (Jeekel, 2011).
5.2 Differences in Goal Formulation

The choice to involve groups that understand the practice of cycling and the systems that support it reflects the overall approach of the Bicycle Master Plan. While the goal of the project was to reduce auto use, the measurement of whether or not that goal was achieved was formulated from the perspective of cycling rather than driving. Specifically, the original policy document for the Bicycle Master Plan stated that the primary goal of the project was to achieve an increase of 3.5 billion (or 30%) kilometers travelled by bicycle between 1986 and 2010. This goal was calculated to be the equivalent of an 8.75% reduction in the total number of auto kilometers travelled (Directoraat-generaal Personenvervoer, 1997).

This approach meant that the achievement of the goal was not entirely reliant on people who drove shifting to cycling. The 24-year time span also allowed for the goal to be achieved by improving bicycle infrastructure so that fewer people chose to defect from their cycling practice and purchase an automobile. The shift from driving to cycling could therefore also be accomplished through a generational shift in which younger people chose to continue cycling instead of purchasing a car while older individuals drove less as a result of retirement and age-related issues.

With the Bicycle Less Congestion defined its goal differently than the Bicycle Master Plan. Rather than attempting to increase the number of kilometers cycled, that stated ambition of the project was to reduce the number of mid-range car trips on the highways near the bicycle infrastructure by 5% (Van Boggelen, 2010). This project goal was reflected in the cost-benefit analysis created by the ministry responsible for With the Bicycle Less Congestion. The tool specifically assigned value to number of people who switched from driving to cycling as a result of the infrastructure, but assigned no value to the retention of existing cyclists (Van Ommeren et al., 2012).

The projects funded and implemented under the policy of the Bicycle Master Plan reflect the broad approach allowed by the governance structure and reveal an orientation towards the practices of current cyclists. Even though a modal shift from driving to cycling was one of the principal objectives of the policy, the actual projects that were implemented under this focal point demonstrate how the project considered supporting the practices of existing cyclists to be a key component of this modal shift goal. While some projects, such as research into how driving trips could be replaced by cycling trips and informational material for employers on encouraging cycling, were focused exclusively on people who currently drove, other projects listed under the modal shift goal were oriented towards simply improving the experience of those who cycled. Projects of this type included research on the economic value of bicycle traffic, research on history of bicycle use and bicycle policy; pilot projects on wind protection for cyclists, wayfinding signs, and streets where bicycles have priority; guidelines for the development of bicycle friendly infrastructure, for the maintenance of bicycle paths, and for the inclusion of local bicycle connectivity planning around transportation infrastructure projects for other modes; and information exchanges on bicycle policy both between Dutch cities and between the Netherlands and other countries interested in Dutch bicycle policies (Directoraat-generaal Personenvervoer, 1997).
5.3 **Differences in Acquiring Knowledge about the Target Group**

The different way each project had of formulating its end goal carried over into different approaches for how each project acquired the project development knowledge considered necessary to achieve that goal. Because the focus of With the Bicycle Less Congestion was on changing the behavior of drivers, the project used people who drove as the knowledge base for policy considerations. In order to determine the effectiveness of the first five bicycle highways built under the project, an online survey was conducted prior to the construction of the infrastructure that targeted people who drove along the five routes but who could have chosen to bicycle instead. The responses of this group were compared with responses from people bicycling on the route after the improvements were made.

The online survey asked respondents to evaluate 15 different hypothetical trips in which respondent could choose to travel either by bicycle or by car. The purpose of the survey was to evaluate how elements such as crossings, traffic lights, cycle path surface quality, and lighting would affect people’s decision to use the bicycle route. Five thousand people responded to the e-mail but only 497 responses were ultimately used in the evaluation of the bicycle infrastructure. The preferences of many respondents were not included in the evaluation because the survey was intended only for people who mostly drove to work and could potentially either start using a bicycle or bicycle more frequently. Therefore, a person’s preferences for bicycle infrastructure would only be included if that person met the following conditions:

- They had a driver’s license.
- They had a paid job.
- They lived in the area of one of the bike routes under consideration
- They sometimes drove on the highway along one of the routes under consideration
- They sometimes drove to work during rush hour.
- They had a commute that was occasionally shorter than 20 km in one direction.

If a person did not meet all of these conditions, they were not included in the survey. The largest number of participants from the survey on bicycle highways were rejected because their commute was not likely to be made by bicycle (1,891 people), they did not have a driver’s license (1,178 people) (Muconsult, 2007).

The design and evaluation of the With the Bicycle Less Congestion program reflects its narrow definition of a transition from driving to cycling. Interpreted through the lens SPT, the survey attempts to gain knowledge about what makes the practice of cycling attractive by questioning people who do not engage in the practice and excluding the people that do. One of the challenges of encouraging people to switch to other modes is that people who do not cycle regularly often have a more negative attitude towards cycling (Namgung and Jun, 2019; Oosterhuis, 2015). Their ideas about what would be needed to bring them to cycling might not be reflective of the actual practice of cycling. Perhaps more importantly, one study showed that 95% of the people on new bicycle highways were existing cyclists (Skov-Petersen, Jacobsen, Vedel, Thomas Alexander, & Rask, 2017). By specifically excluding the vast majority
of potential users from the survey, the project risks fundamentally misunderstanding what would make the infrastructure attractive to cyclists, the stated goal of the survey.

This stands in stark contrast with the Bicycle Master Plan. While the advisory committee comprised of various stakeholders may have been active primarily in the early years of the project (Directoraat-generaal Personenvervoer, 1997), their inclusion as part of the project structure from the beginning underscores the difference between the two projects in their approach to acquiring knowledge for policy development. The early focus on existing cycling practices in the Bicycle Master Plan, the project that focused on increasing the number of kilometers cycled, and the absence of interest in existing cycling practices in With the Bicycle Less Congestion, the project that focused on reducing congestion rates, suggests a relationship between how a project formulates its modal split goals and how it develops its policies. How a project conceptualizes model split, therefore, has implications for both theory and practice. In the discussion section that follows, we will explore these implications as well as the limitations of including a focus on practice maintenance in relation to a sustainable transportation transition, with particular attention to possible areas for further research.

6 Discussion

The starting point of this paper is the argument that the current literature does not give enough attention to the maintenance of existing sustainable transportation practices when considering how SPT theory can be applied to achieving sustainable transportation goals. Through comparing two Dutch cycling policies, we have discussed the value of the maintenance of sustainable transportation practices. In this section we consider how specifically a focus on the maintenance of practices could be developed, addressing the limitations of current conceptualizations of mode shift and defining an alternative conceptualization that includes a focus on maintenance. We then briefly discuss how this concept of mode shift could be translated into policy. Finally, we reflect on the implications of our findings outside of a specifically Dutch context and suggest possible areas of further research in relation to other countries and other modes of transportation.

6.1 Incorporating a Maintenance Based Mode Shift Approach into Cycling Investments

When trying to achieve mode shift goals, programs such as With the Bicycle Less Congestion focus on convincing people who drive to cycle instead – a challenging transition given the obstacles associated with car dependency (Jeekel, 2011; Oosterhuis, 2015; Shove et al., 2015). As argued by Spotswood et al. (2015) from the perspective of SPT, shifting from driving to cycling requires identifying the missing breaks in meaning, materials and competencies that create obstacles to the practice of cycling and finding ways to use policy to remove these obstacles. Changes to the cycling experience, however, will not affect people who do not cycle, and therefore may have little influence over their established practices.
By viewing the modal choice of commuters as an individual choice and by viewing a modal shift as consisting solely as a choice to stop driving and start cycling, With the Bicycle Less Congestion restricted itself to relying for its success on a group that may consist largely of car dependent people resistant to change. By viewing modal choice as part of a complex and interconnected series of practices by diverse groups of actors and by viewing modal shift as both a change from driving to cycling and a continuation of existing cycling practices over time, the Bicycle Master Plan created an umbrella program that was able to support an enormous diversity of projects under its policy framework and use the knowledge of those who actively cycle and those directly connected to the cycling system to work towards its goals.

Stated another way, With the Bicycle Less Congestion considered mode substitution only in the form of car trips that could potentially be taken by bicycle, while the Bicycle Master Plan’s approach reflected a broader conceptualization of substitution formulated by Piatkowski et al. (2015) in which a person who cycles for all of their trips and does not own a car is substituting all driving trips for bicycle trips.

Because the cost-benefit analysis developed for bicycle infrastructure in the Netherlands does not factor in this latter type of substitution (Van Ommeren et al., 2017), cycling investments are evaluated based only on people who potentially may cycle rather than people who are already engaged in the practice. The cost-benefit analysis, therefore, does not allow for a calculation of the benefits of a maintenance-based approach that includes a focus on improving the experience existing cyclists in order to achieve a long-term increase in sustainable transportation practices. Future research could explore how this approach could be incorporated into the evaluation of cycling investments.

6.2 Possibilities for Practical Application of a Maintenance Based Approach to Dutch Cycling Policy

In the Netherlands, the elements of cycling practice are established by a large portion of the population at a young age. As people get older, cycling rates generally drop (Centraal Bureau voor de Statistiek, 2018). This statistical drop in cycling was confirmed by a longitudinal study on cycling habits in Netherlands that showed that people under 30 were the most likely to change from a cycling commute to a car commute (Oakil, Ettema, Arentze, & Timmermans, 2016). A possible reason for this decline is suggested by the findings of a government report that found people’s decision to purchase a car in the Netherlands is frequently paired with a major life event, such as starting a new job, having a baby, or retiring (Kennisinstituut voor Mobiliteitsbeleid, 2014).

The high cycling rate in the Netherlands, therefore, is not a result of a large number of people having chosen to give up their cars and start cycling instead, but rather the result of people who grew up cycling and who continue to do so. Since cycling rates are highest among younger people, cycling rates can also be increased (and driving rates decreased) by lowering the number of people who shift from cycling to driving after a major life event.
Whatever the meanings, materials, and competencies that form the practice of cycling are, people who are regularly engaged in the practice of cycling, by definition, possess them. The challenge becomes determining how these elements change during transitional events that lead people to stop cycling. As the approach of the Bicycle Master Plan demonstrated, one way to meet this challenge is by bringing together as many representatives of all the diverse practices involved with the system of cycling and investing in strengthening those practices throughout the system.

The principle of social feedback (Skov-Petersen et al., 2017) suggests that people look to the experience of others when evaluating their own future experience. Improving the cycling experience for commuters that cycle between cities, people with children, or retired people, for example, increases the chances that people who already cycle will have a positive model for adapting their meanings, materials, and competencies when faced with a new commute, the arrival of a child, or their approaching retirement. Focusing on improving conditions for existing cyclists, therefore, also results in better conditions for people evaluating what their cycling experience will be like in relation to their new job, their new child, or their retirement lifestyle and this may also result in a reduction of people changing from cycling to driving. While these events take place at various points in the life cycle, this approach would not necessarily require waiting a generation to see results. If the number of people who would have started driving in a given year but continued to cycle because of an intervention is higher than the number of people who stopped driving and started cycling in that same year, the maintenance-based approach would, by definition, be the one providing better short-term results.

Further research would be required to determine which interventions would have the most potential at these transition points.

6.3 ADAPTING A MAINTENANCE BASED APPROACH IN OTHER COUNTRIES AND FOR OTHER MODES OF TRANSPORTATION

The Netherlands has a significantly higher cycling rate than other countries (European Union Economic and Social Committee, 2011). For example, in the United Kingdom, cycling trips comprise approximately 2% of all trips (Spotswood et al., 2015) and in Australia the rate is closer to 1% (Harms & Kansen, 2018) while in the Netherlands 27% of all trips are made by bicycle (Harms & Kansen, 2018). This could be one explanatory reason for the absence of scholarly attention to maintenance of sustainable transportation practices, particularly in relation to cycling.

However, while the cycling rate may be higher in the Netherlands, life events have been shown to be associated with changing cycling practices in other countries as well. A study in the United Kingdom used interviews with residents in towns with improved cycling infrastructure to show that changes in cycling were often triggered by life events (Chatterjee, Sherwin & Jain, 2013). An Australian study found that decreases in cycling rates among women
were linked to many of the same events listed in the Dutch study of auto acquisition (moving to a new house, starting a new job, and having children) (Bonham & Wilson, 2012).

While the potential benefits of the maintenance of cycling practices is obvious in a country with a high cycling mode share like the Netherlands, investing in the maintenance of practices could also be of benefit in countries with a lower cycling mode share. For example, in Great Britain 1% of all vehicle miles travelled are travelled by bicycle. This 1%, however, is not distributed evenly across the population. Males made 2.5 times as many cycle trips as females and cycled 3.6 times as many miles. Across areas of Great Britain, younger age groups had higher cycling rates than older age groups (Cycling UK, 2019). This suggests a cycle of recruitment and defection, with a new set of younger male cyclists continuously replacing their older counterparts. While the literature on risk perception and its relationship to cycling remains limited (Wardlaw, 2014), young males have been shown to have higher risk tolerances in other transportation contexts (Hulse et al., 2018; Turner and McClure, 2003) and the decision not to cycle has been linked to perceiving cycling as a dangerous activity (Heinen et al., 2011; Manton et al., 2016). This could potentially be one explanatory factor for the growth in U.S. cycling rates coming almost entirely from men, with cycling rates for women stagnating and those for children dropping substantially (Pucher et al., 2011). To increase cycling rates, policymakers could not only focus on expanding the bicycle network along commuting routes, but also invest in making the existing network safer, decreasing the risk tolerance necessary to cycle. As bicycle safety improvements have already been shown to attract new cyclists (Noland, 1995), safety improvements would also seem likely to reduce the number of people who stopped cycling as their risk tolerance increased with age.

For example, a hypothetical city could have a stable cycling mode share of 2%, but every year have 20% of people cycling for the first time and 20% of people choosing to no longer cycle. If the number of people who chose not to stop cycling was cut in half, the city would double its cycling mode share to 4% within 7 years as 10% more people started the practice than stopped among an ever-increasing active group of cyclists.

Further, a maintenance-based approach to a sustainable transportation mode shift need not be limited to the practice of cycling. The argument that investing in the maintenance of sustainable transportation practices has value still holds for other modes of transport in other countries. A large body of literature exists examining the effects of programs aimed at convincing people to stop driving and take public transportation instead (Adler & Van Ommeren, 2016; Anderson, 2013; Beaudoin & Farzin, 2015; Duranton & Turner, 2011; Pang, 2018; Salon, Boarnet, Handy, Spears, & Tal, 2012). While evaluating a modal shift from driving to public transportation in the context of SPT is beyond the scope of this paper, the argument made here that existing cyclists can be part of a mode shift in a country where most of the population begins cycling at a young age could potentially be used to argue for a focus on maintaining current ridership levels in a city, region or country where practices of transit use start at an early age. One key similarity between the Netherlands and the United States, England, Australia and many other countries in Europe is a trend towards acquiring a driving license at a later age (Delbosc and Currie, 2014; KiM, 2014; Le Vine and Polak, 2014; Ortar et
al., 2018; Schoettle and Sivak, 2014; Thigpen and Handy, 2018) Future research could expand on an Australian study that examined the multiple reasons millennials were choosing to delay getting driving licenses (Delbosc and Nakanishi, 2017) and explore how maintenance based approaches to not only cycling but also walking, ride sharing and public transit could support the sustainable transportation practices of young adults and further raise the average age at which many young adults shift to driving.

7 CONCLUSION

While the existing body of literature uses SPT to discuss which policies might support a change to sustainable practices, possibilities to use SPT to understand how existing sustainable practices can be supported to further sustainability goals have not been explored. Addressing this gap, our paper articulates an approach to achieving mode shift in the direction of sustainable transportation through a focus on the maintenance of existing sustainable transportation practices.

Drawing on two national Dutch cycling policy programs that illustrate two different possible approaches to a mode shift in favor of cycling, we have argued that investing in a maintenance-based approach could contribute to achieving the modal split goals set by change-based approaches. Specifically, we compared the Bicycle Master Plan (1991-1997) to With the Bicycle Less Congestion (2006-2009). While the first program, took a broad approach and considered any element that would improve the chance of increasing cycling rates over the long term, the latter invested all of its resources in a very specific approach: promoting a shift from driving to cycling by targeting people driving on congestion prone routes and investing in changes that might encourage them to change their behavior and choose to cycle instead.

This paper, therefore, both contributes to the scholarship on sustainability and behavior change that uses SPT with the goal of advising policymakers and to the debate on transitions to sustainable transportation by articulating a new approach to achieving mode shift that can provide a broader understanding of the policy options available.

This maintenance-based approach could apply to any situation in which a large number of people have a sustainable practice but might change to an unsustainable practice (areas with high levels of cycle or transit ridership, for example).

We do not suggest that no investments should be made in encouraging people to move from unsustainable to sustainable transportation practices; rather, we argue that the maintenance of sustainable transportation practices represents an approach missing from the policy toolkit that could complement and support current investments.

Specifically, focusing exclusively on a narrow definition of mode shift that only includes people who go from unsustainable to sustainable practices fails to take into account the potential
benefits of a broader definition of mode shift, one that includes a focus on the maintenance of existing sustainable transportation practices over the whole life cycle.

Acknowledgments

The authors would like to thank everyone who provided support in the development and revision of this chapter, including Frank Schipper, Ruth Oldenziel, and all the members of the Sustainable Urban Mobility research team. The authors assume responsibility for all error
Chapter 6: Conclusion

The introduction of this dissertation began with a comparison of my personal experiences cycling in San Francisco and the Netherlands. When riding in San Francisco’s Critical Mass, participants often spoke about how the group ride through the city was the only time they really felt safe when riding a bicycle. As much as out of livability and environmental concerns, the activism of Critical Mass seemed to be driven out of a sense of self-preservation. People who cycle were vocal in their demands for improvements to the cycling system because those improvements could literally be a matter of life and death. Living in an environment where we found it a struggle for officials to take cycling as a mode of transportation seriously, the cycling innovations in mature cycling countries seemed a clear demonstration that the needs of people who cycle are worth addressing. The research in this dissertation suggests, however, that the attention given to the implementation of cycling innovations can overshadow the role that those innovations play in the transportation system.

Low cycling places proclaim, “if you build it, they will come,” (Félix et al., 2020; Krizek et al., 2007; Lugo, 2013; Porter et al., 1999). This dissertation has shown that in a high cycling context, much was built because people who cycle were already there. The safety in numbers principle is often used to describe how the rate of collisions generally goes down as the number of people cycling or walking in a given area increases (Elvik, 2009; Fyhri et al., 2017; Jacobsen, 2003). With the highest cycling rates in the world, cycling policy in the Netherlands no longer feels like a matter of life and death for many. Chapter 4 on cycling activism in the Netherlands in the 1970s shows this feeling reflects the attitude of those who presently cycle in the Netherlands. As historian Stoffers remarked about people who cycle in the Netherlands, “Cycling is not remarkable enough to pay a lot of attention to” (2012, p. 93). While cities in the Netherlands may have a much greater willingness to make cycling related investments than cities such as San Francisco, the investments made in the Netherlands may not be as closely scrutinized as cycling investments in places with lower cycling rates but higher levels of cycling activism. This distinction is important when considering which innovations from the Netherlands could be helpful for other places looking to increase cycling rates.

The Netherlands should not be seen only as a success story to be emulated elsewhere. In a larger historical context, cycling rates had dropped significantly from high levels in the Netherlands since the late 1950s before levelling off in the 1970s. In other places, they collapsed entirely. While the Netherlands has implemented several innovations to maintain cycling rates higher than its neighboring countries, its own steep decline in cycling rates historically is a reminder of the potential fragility of the cycling system. Rather than policymakers directing the development of cycling innovations entirely towards the recruitment of new cyclists, investing in existing cyclists provides two key benefits: it both protects the cycling system that has already been established and gives it the potential to grow by reducing the number of people who give up cycling at some point in their lives.

This argument reflects one of the central problems identified and examined in this dissertation: cycling has the potential to play a key role in the urgent need for a transition to
sustainable mobility systems; the role of cycling innovations in that transition, however, had
not received much attention. Scholarship had already established that people who cycle play
an important role in advancing cycling systems (Albert de la Bruhèze & Veraart, 1999;
Oldenziel, Emanuel, Albert de la Bruhèze, et al., 2016) but their role in cycling innovations was
not well understood.

This dissertation addressed that gap in the research by applying critical mobility scholarship to
theories of reconfiguration in order to examine the role of cycling innovations in the
Netherlands—the country with the highest cycling rates in the world (Goel et al., 2021; Harms
et al., 2014). These innovations have been used as a model in many places looking to increase
their own cycling rates (Candelari, 2020; Chang, 2017; Koster, 2014; Pucher & Buehler, 2008;
Rudick, 2021), but without a focused analysis of the role they actually play in the Dutch cycling
system, where the consistency of cycling rates over the past 50 years makes it difficult to
separate the effects of historical activism from recent policy interventions (Oldenziel,
Emanuel, Albert de la Bruhèze, et al., 2016; Reid, 2017). With the Netherlands looking for ways
to raise its own cycling rates (Tour de Force, 2017), a better understanding of the role of
innovations in the cycling system was necessary for the advancement of transition goals in
places with both high and low cycling rates. This problem was addressed in this dissertation
through the following central research question:

How can the insights from critical mobility scholarship be combined with theories of
reconfiguration processes to allow for a better understanding of the role of cycling
innovations in a mature cycling country, including how these innovations can be used
to support people who cycle in order to advance a transition to sustainable mobility?

The research presented here answered this question by demonstrating that people who cycle
drive cycling innovations in two distinct ways. Each have implications for a transition to
sustainable mobility systems. First, people who cycle have been influential in the development
and implementation of cycling innovations that restrict the parking, access, and speed of cars,
allowing for the creation of spaces in which cycling is a safe and effective form of
transportation. Second, people who cycle have been seen as slowing down cars, leading to
innovations that manage people who cycle in order to increase the efficiency of the system of
automobility. Understanding this distinction is important for both expanding cycling rates
within the Netherlands and for deciding which cycling innovations would best advance
sustainable transportation goals outside of the Netherlands.

The dissertation also argues that innovations directed towards supporting people who already
cycle—rather than only focusing on attracting new cyclists—can effectively advance a
transition to sustainable mobility systems. Addressing the reasons why people give up cycling
after life events like the birth of a child, starting a new job, moving, or retirement can lead to
more people cycling for longer periods. In both high and low cycling contexts, using cycling
innovations to support the maintenance of cycling practices keeps the existing cycling system
healthy while also increasing the total number of people cycling by extending the number of
years that people find cycling their best option for transportation. The dissertation argues that
the innovations that best support a transition to sustainable mobility systems are those based
on the knowledge, experience, and activism of the people that produce, reproduce, and maintain the cycling system through their daily practices.

This conclusion is developed through a four-part structure, showing how each chapter of the dissertation addresses a different aspect of the central research question. The following sections provide an overview of how each of these sub-questions were answered and then return to the central research question to provide an expanded explanation of the results described above. This is followed by a reflection on the limitations of the dissertation and an outline of potentially fruitful avenues for future research. The conclusion closes with a brief overview of the policy implications of the research.

1 KEY CHAPTER RESULTS

1.1 KEY RESULTS OF CHAPTER 2, CYCLING AND TRANSITIONS THEORIES: A CONCEPTUAL FRAMEWORK TO ASSESS THE RELATIONSHIP BETWEEN CYCLING INNOVATIONS AND SUSTAINABILITY GOALS

The second chapter presented a framework for the analysis and evaluation of cycling innovations that was used throughout the dissertation. It addressed the following sub-question:

How can the sustainable mobility paradigm be combined with the theories of the multi-level perspective and strategic niche management to evaluate whether or not cycling innovations support people who cycle and advance sustainability goals in their context of implementation?

Through application of the sustainable mobility paradigm to the multi-level perspective and strategic niche management, the chapter showed how cycling innovations that can advance sustainability transitions are those that challenge conventional planning approaches by prioritizing people who cycle and slowing down the travel speeds of those who drive. The chapter also demonstrated a distinction between cycling innovations modified upon implementation to lessen their challenge to automobility and those developed and implemented for the specific purpose of supporting automobility. It demonstrated the importance of this distinction when considering implementing cycling innovations intended to advance a transition to sustainable mobility systems in both high and low cycling contexts.

1.2 KEY RESULTS OF CHAPTER 3, MOBILITY PROTESTS IN THE NETHERLANDS OF THE 1970s: ACTIVISM, INNOVATION, AND TRANSITIONS

The third chapter took the theoretical concepts introduced in the previous chapter and applied them to cycling innovations that came out of a specific historical context. It did this by addressing the following sub-question:
In mature cycling countries, how can the strategic niche management principle of protective space be used to understand the role of historical social movements in the implementation of innovations that successfully challenged automobility?

The chapter answered this question by demonstrating how social movements can function as an effective form of protective space, advancing innovations that challenged automobility and supporting the long-term success of cycling as a sustainable form of transportation in the Netherlands. People who cycle combined protest actions that garnered broad public support with direct talks with local and national lawmakers. Their activism led to changes in policies and regulations that allowed car restricting innovations, including the woonerf, car restricted city center, and bottleneck memorandum. Communication and co-ordination between groups resulted in the adoption of these innovations across the country. The article connected these developments with the stabilization of cycling rates in the Netherlands, rates that continued to drop dramatically in other European countries. It showed how this creation of safe spaces to cycle remains a key element in the maintenance of high cycling rates in the Netherlands, demonstrating the long-term influence that people who cycle had in creating the high mode share of sustainable transportation that other countries aspire towards.

1.3 KEY RESULTS OF CHAPTER 4, THE CHALLENGE OF THE BICYCLE STREET: APPLYING COLLABORATIVE GOVERNANCE PROCESSES WHILE PROTECTING USER CENTERED INNOVATIONS

Chapter 4 provided a contrast to the third chapter, which showed the positive impacts of car-restricting measures for promoting sustainable transitions. This chapter demonstrated how accommodations for automobility can reduce the effectiveness of innovations designed to support people who cycle. It demonstrated this by answering the following question:

In mature cycling countries, how can the strategic niche management principle of protective space be used as a means of analyzing how collaborative governance processes can compromise innovations intended to challenge automobility?

The article used a case study to illustrate the effect that collaborative governance processes can have on the development of protective spaces for niche cycling innovations. It showed the relevance of these processes with a specific bicycle street in the Netherlands where the effectiveness of a cycling innovation was significantly reduced by those interested in maintaining the system of automobility. The case provided an instance in which the bicycle street was not used to improve safety and access for cyclists, but to secure approval on a project from people concerned about loss of access and parking for those driving.

Reflective of the framework presented in the first chapter that demonstrated that not all cycling innovations advance sustainable transportation goals. The case showed the processes that changed this cycling innovation from one that supported people who cycled into one that preserved the system of automobility. The case served as an effective example because of the clarity of the process: traditional separate infrastructure was proposed and agreed upon by
residents and representatives of people who cycle. Ultimately, however, the bicycle street innovation was implemented based on the concerns of those representing people who drive. This compromise has resulted in a bicycle street that has been the source of safety complaints and concerns since its implementation and where the majority of the people cycling yield to people driving. The case thus demonstrated the risks of assuming that a process focused on consensus and collaboration will result in the successful implementation of an innovation intended to help one specific group.

1.4 Key results of Chapter 5, Towards a maintenance-based approach to mode shift: Comparing two cases of Dutch cycling policy using social practice theory

Chapter 5 combined the analysis of the previous three chapters to present a framework for how innovations that support existing cyclists can be used to increase cycling rates. It did this by addressing the following sub-question:

How can social practice theory be used to demonstrate the potential benefits of implementing innovations directed towards people who cycle?

The chapter draws on social practice theory showing how changing driving practices to cycling practices involves both changing the materials, meanings, and people’s competencies regarding cycling and addressing the interconnected practices that may keep them car dependent. It demonstrated that innovations directed not at changing practices but maintaining them could also result in a significant shift to sustainable modes.

The article used the extensive cycling data from the Netherlands as a mature cycling country to show a clear pattern: in general, people cycle more when they are young. Certain life events – the birth of a child, buying a house, starting a new job – often lead them to purchase a car. The article examined the effects of investing in ways to keep people cycling after these transformative events. It outlined the rather straightforward logic of this approach: if the number of people who take up cycling remains constant (young people using the bicycle as a mode of transportation before they can drive) but the number of people who stop cycling as they become older decreases, the overall number of people cycling will increase, as will the ratio between those cycling and driving, as the continuation of cycling practices would result in reduction in the adoption of driving practices.

The article illustrated the potential effectiveness of this approach by comparing two actual cycling policies. The first focused entirely on people driving, encouraging them to take up cycling through the construction of high-quality cycle lanes near highways. The second focused on increasing cycling rates by basing investments around the needs of people who already cycled, with the improvements based on their knowledge and experiences. The article examined a program that invested in developing cycling planning knowledge within cities, improving the connections between cycling and transit, increasing the safety of people who cycle and decreasing bicycle theft. The investments were developed in consultation with the
national cyclists’ union and other organizations with direct knowledge of the needs of cyclists, including local city planners and bicycle national bicycle manufacturers. Whereas the first program measured success by the number of people who switched from driving to cycling, the second program measured success through an increase in the total amount that people cycled. By placing the focus on the actual needs of people who cycled rather than the projected needs of people who may potentially cycle in the future, the second program demonstrated how innovations directed towards the barriers faced by people who may be new to cycling and the concerns of those who already cycled creates the possibility of increasing cycling rates by extending the period in which people who cycled maintained their cycling practice.

2 OVERALL RESULTS AND CONTRIBUTION

The dissertation contributed to the scholarship on the application of theories of reconfiguration through its incorporation of insights from critical mobility literature. This section presents an overview of how this novel approach addressed the central research question, clarifying the contributions of the dissertation through a summary of its key two findings.

First, not all cycling innovations support a transition to sustainable mobility systems within the framework of the sustainable mobility paradigm. Some cycling innovations prioritize improving the system of automobility rather prioritizing the needs of people who cycle.

Second, people who already cycle can play a valuable role in the transition to sustainable mobility systems, as they can advance the development and implementation of sustainable transportation innovations and their daily practices contribute to a shift to sustainable mobility systems.

In developing these findings, this dissertation addressed a significant gap in the literature on the application of theories of reconfiguration to sustainable modes of transportation. Previous scholars who had applied transitions theories to transportation systems focused largely on transitions related to the system of automobility (Fraedrich et al., 2015; F. W. Geels, 2005, 2012; Hoffmann et al., 2017; Kemp et al., 2012; Marletto, 2014a; Urry, 2004). The role of cycling innovations in transitions had not received attention as the focus of analysis even though efforts to increase cycling rates would benefit from a better understanding of the role of innovations in the cycling system in both low and high cycling contexts. Additional knowledge on the role of cycling innovations was particularly necessary in the context of places with high cycling rates where the innovations that are implemented become a model for places with lower cycling rates (Candelari, 2020; Chang, 2017; Koster, 2014; Pucher & Buehler, 2008; Rudick, 2021). This dissertation addressed this research gap by examining the role of Dutch cycling innovations in the context of critical mobility scholarship. It provided a general framework for evaluating the role of cycling innovations in sustainability transitions.
and examining specific cases to better understand the relationship between people who cycle and cycling innovations.

This dissertation explored multiple challenges for policymakers interested in developing and implementing innovations to advance a transition to sustainable mobility systems where cycling plays a key role. It provided a framework for understanding how some cycling innovations advance automobility and demonstrates the difficulty of implementing innovations that challenge automobility. It also showed how innovations intended to serve people who cycle can end up being repurposed to advance the interest of those who drive. In attempting to use cycling innovations to advance sustainability goals, it also revealed the challenges of focusing entirely on trying to convince people who drive to take up cycling, arguing that focusing on people who already cycle could potentially be equally effective but without the barriers associated with changing practices.

Places with low cycling rates often seek to copy the innovations found in mature cycling countries like the Netherlands (Candelari, 2020; Chang, 2017; Koster, 2014; Pucher & Buehler, 2008; Rudick, 2021). This dissertation demonstrated how the high cycling rates themselves shape the cycling innovations produced in the Netherlands. In doing so, it challenges the causal claim used to describe cycling investments in much of cycling research: if you build it, they will come (Félix et al., 2020; Krizek et al., 2007; Lugo, 2013; Porter et al., 1999). Instead, it examined how cycling innovations have developed because people who cycled were already there.

This has occurred in two distinct ways, each with consequences for achieving a long-term mode shift. The first involves innovations advanced by people who cycle and the second involves the innovations created to manage people who cycle in support of automobility. Historically, the large number of people who cycled in the Netherlands created broad support for innovations that advanced cycling through restrictions on automobility. High cycling rates throughout the country, and the active engagement of people determined to protect their communities from the increased pollution, injury, and death that came with the process of automobility, led to organized and connected groups that not only advocated for the implementation of different types of cycling innovations, but actively aided in their development. These groups worked to reclaim space for people who cycled, objecting to how the demands for greater efficiency in the automobility system were pushing them out of the way.

While these groups succeeded in advancing many key innovations in support of people who cycle, they did not end the process of implementing cycling innovations for the benefit of people who drive. Cycling research is often directed at innovative ways to manage people who cycle to increase the efficiency of the car system (Hamilton & Wichman, 2018; Van Boggelen, 2010; M. Wang & Zhou, 2017; Y. Wang et al., 2020). This dissertation demonstrated how the system of automobility can influence cycling innovations and impact the advancement of sustainability goals through the application of strategic niche management principles to a case study on the transformation of the bicycle street. It showed how the cycling innovation had been changed from an innovation intended to create safe and complete bicycles networks on
a limited budget to an innovation for protecting car parking and car access in places with limited room for bicycle lanes.

Rather than only providing a means for evaluating whether or not cycling innovations support sustainability goals, the dissertation demonstrated a specific approach for increasing cycling rates by implementing innovations based on the needs of people who already cycle. It compared two cycling policies with two distinct approaches: one that focused on developing cycling innovations around the needs of people who drove and one that focused on the obstacles faced by people who already cycled. This comparison showed that using the knowledge of people who already cycle in order to keep them cycling could increase the cycling mode share with fewer obstacles than a policy approach that relied on reversing car dependency. It argued that building a cycling system around existing users is an approach that could prove effective in both high and low cycling contexts. In high cycling contexts, it would extend the usefulness of the cycling system to more people at different life stages. In low cycling contexts, it would help identify the barriers that cause people to give up cycling, increasing cycling rates over the long term both by retaining existing cyclists and making the cycling system more attractive to new users.

Taken together, the dissertation demonstrated that in a mature cycling country, people who cycle advance innovations that support their needs but also serve as the impetus for innovations designed to manage them to improve the efficiency of the system of automobility. In the Netherlands, the continued maintenance of the highest cycling rates in the world comes in part from innovations developed and advocated for by people who cycle. These large cycling rates, in turn, have led to innovations designed to limit the interference of cyclists with automobility. When using the Netherlands as a model for sustainability advancing innovations, the difference between innovations that support people cycling and innovations that manage them to support automobility is a crucial distinction. Maintenance-oriented innovations directed towards supporting people who already cycle can effectively advance a transition to sustainable mobility systems. Addressing the reasons that people give up cycling after key events can lead to more people cycling for longer periods. Regardless of the level of cycling rates, using cycling innovations to support the maintenance of cycling practices can keep the existing cycling system healthy and increase the total number of people cycling by extending the number of years that people cycle. The innovations that support a transition to sustainable mobility systems are not limited to those that make cycling attractive for people driving but also include those that build on knowledge, experience, and activism of the people reproducing the cycling system through their daily practices.

3 LIMITATIONS AND FURTHER RESEARCH

The dissertation applies theories of reconfiguration to critical mobility scholarship in order to present a framework for evaluating which cycling innovations best support sustainability and demonstrates how people who already cycle can support a transition to sustainable mobility systems. Each of the dissertation chapters suggest a path forward to resolve the challenges
presented but the analysis comes with limitations. This section describes three of those limitations and the additional research that would be necessary to address them and further extend the analysis presented here.

The first limitation of the research is that the system for evaluating the sustainability of cycling innovations applies only to innovations that have already been implemented and does not cover innovations that were developed but did not receive enough support to be implemented. Understanding the social and political processes behind unsuccessful innovations would provide valuable insights into how different mobility regimes adopt, alter, or reject cycling innovations and the role of people who cycle in those processes. Further research is needed to understand the development of cycling innovations, including why some innovations that could advance sustainability goals are not implemented. This would also include an examination of the processes that result in a cycling innovation that is successful in one mobility regime being proposed but not successfully implemented in a different mobility regime.

The second limitation of the research is that it centers primarily on the Netherlands as a mature cycling country. While this choice was made deliberately to interrogate the role that the Netherlands plays as a model for other countries looking to increase their cycling rates, the analysis would have benefited from a closer examination of cycling in other geographic contexts, particularly places with low cycling rates but high levels of cycling activism. Examining these places and comparing them to the Netherlands, a place with high cycling rates but low levels of activism, would allow for better understanding of the relationship between cycling rates and cycling activism. Further research is needed to understand these two different but related challenges: how a country with high cycling rates but low levels of activism can continue to develop a cycling system that supports those who use it and how places with low cycling rates, but high levels of activism, can succeed in implementing the types of car-restricting innovations that allowed cycling to thrive in Netherlands. While the dissertation identified the key role that activists played in sustaining cycling rates, it also notes the decline in the culture of activism around cycling in the Netherlands. The long-term effects of the decline of activists' involvement on cycling policy and its implications for the Netherlands as a model cycling country need to be better understood and an analysis of the processes behind cycling innovations being developed in lower cycling contexts could help with this understanding. This would involve additional research on how cycling innovations can be protected in ways that minimize resistance from people invested in automobility while ensuring that they serve the interests of people cycling.

The third limitation of the research presented here involves the presentation of a broad framework for the maintenance of cycling practices that does not include a detailed analysis of the specific interventions that would make that framework possible. Further research should expand on the specific types of innovations that would allow people to continue cycling after key life changes including the birth of a child, starting a new job, moving, and retirement. Understanding how people’s transportation practices change throughout the life cycle and
how people can be supported during these changes is necessary to ensure that sustainable forms of transportation remain a viable and preferable option for them.

Further research could expand the findings of this dissertation in two different ways. First, additional research is needed on what types of innovations support existing cyclists. Second, research is also needed on how the knowledge and power of existing cyclists can be harnessed to develop and implement those innovations, both in mature cycling countries and starter cycling cities. This additional research could refine, expand, and confirm this dissertation’s framework for understanding how people who cycle can advance innovations that contribute to a transition to sustainable mobility systems with additional attention for locations outside of the Netherlands.

4 Policy Recommendations

The section that follows describes the relevance of this dissertation for policymakers interested in advancing a transition to sustainable mobility systems. It provides suggestions for policymakers interested in using cycling innovations to advance a transition to sustainable mobility systems. It provides specific suggestions that advocate two main approaches: (a) deprioritizing cycling innovations that improve the efficiency of automobility and (b) prioritizing cycling innovations that support existing cycling practices. The three examples that follow describe different ways that these approaches could be translated directly into policy.

The first policy recommendation concerns the innovation of the bicycle street. In the Netherlands, the bicycle street is has no legal status, which means that there are not clear guidelines for its implementation. This means it can be used in places with low car traffic to save money on bicycle infrastructure, as its original purpose, and also in places with high levels of car traffic as an alternative to constructing bicycle infrastructure that would result in a reduction in car parking and access. Because this second type of bicycle street can result in an inadequate protection of cycling practices, introducing legally enforceable guidelines would ensure that bicycle streets serve people who cycle rather than protect parking and road access for people who drive. This guidelines would be beneficial not only in the Netherlands, but in any place interested in using the innovation of the bicycle street to help complete missing sections of their bicycle networks.

The second recommendation is to revise the calculation of cost-benefit analyzes to fully capture the effects of cycling innovations. As described in chapter 6, current cost-benefit analysis tools for cycling projects in the Netherlands assign a value to cycling projects that reduce car congestion (Ommereen, 2017). Other countries use the same formulation (Active Communities/Transportation (ACT) Research Group, 2021). The logic is that bicycle projects focused around areas with car congestion will reduce that congestion, creating faster travel times and reducing greenhouse gas emissions as a result. This simplistic model does not consider induced or latent demand (Cervero & Hansen, 2002; Van der Loop et al., 2016), where increasing the efficiency of car travel results in an increased amount of car travel.
Banister’s sustainable mobility paradigm (Banister, 2008) notes that the elimination of congestion has never been considered a realistic possibility and the goal to speed up car traffic as much as possible for travel time savings conflicts with the goal of slowing traffic within cities for safety and environmental reasons. For this reason, the sustainable mobility paradigm argues for defining reasonable travel times rather than working towards travel time minimization.

A cost-benefit analysis that would reflect the sustainable mobility paradigm as applied in this dissertation would assign limited value to bicycle innovations implemented to reduce car congestion. It would include an additional benefit in the evaluation: the contribution that an innovation makes towards encouraging cyclists to keep cycling. If value is assigned to people who stop driving and start cycling, value should also be assigned to people who continue cycling and do not take up driving. This dissertation argues that existing cyclists can advance the development and implementation of sustainable mobility innovations and that their daily practices contribute to a shift to sustainable mobility systems. Recognizing these roles in policy would mean incorporating the value of continuing existing sustainable practices into any cost-benefit analysis of cycling projects.

The third recommendation for policymakers involves investing in innovations that allow people to maintain their cycling practices after key life events. Such maintenance-based policy would improve the cycling experience for people who already commute by bike, people with children, and retired people and encourage these people to continue cycling. It would also help develop positive role models for people who already cycle when they are evaluating their options in preparation for a new commute, the arrival of a child, or their approaching retirement. These innovations would be best developed in consultation with the people whom they are intended to serve but could include projects as small as having baby strollers available at city center bike parking areas (Gemeente Utrecht, 2022) or as expansive as offering a free electric bike to anyone of retirement age.

Advancing a transition to sustainable mobility systems is beneficial for everyone in society, whether or not they cycle. This dissertation demonstrated the importance of seeking out novel ways to address the needs of people who already cycle, as doing so helps both preserve and grow the cycling system in support of sustainable mobility goals. Discovering, developing, and implementing the innovations that can serve this role is a challenge that is as relevant for mature cycling countries as it is in starter cycling cities.
References


Boschman, J. (2013). “Zwolle verklaart de fiets heilig: wie in toekomst nog vooruit wil in de stad, pakt de tweewieler” [Zwolle declares the bike holy: in the future, those who want to get ahead in the city will take the bicycle]. *De Stentor*. 22-6-2021.


Dijkstra, A. (2005). Rotondes met vrijliggende fietspaden ook veilig voor fietsers? [Are roundabouts with separated bike lanes also safe for cyclists?]. In SWOV. https://www.fietsberaad.nl/Kennisbank/Rotondes-met-vrijliggende-fietspaden-ook-veilig-vo?URLReferrer=sort%3D0%253b%26onzeselectiefilter%3D%252fonze%2Bselectie%252ffietsveiligheid%253b%26pagesize%3D10%26page%3D13%26aliaspath%3D%252fKennisbank


146


Mamadouh, V. (1992). *De stad in eigen hand: provo’s, kabouter en krakers als stedelijke sociale beweging* [The city in their own hands: Provo’s, Gnomes and Squatters as city social movement]. Amsterdam: SUA.


151


Environmental Innovation and Societal Transitions. 16, 106–119. https://doi.org/10.1016/j.eist.2015.02.001


COPYRIGHT November 2022 by Matthew Bruno.

All rights reserved. No part of this publication may be reproduced or transmitted in any form or by any means electronic or mechanical, including photocopying, recording, or by any information storage and retrieval system, without the prior permission in writing of the author. For any questions, comments or requests regarding this dissertation, contact Matthew Bruno at m.j.bruno@tue.nl

A catalogue record is available from the Eindhoven University of Technology Library

Cover photo by Matthew Bruno. DLH logo used with permission

There were no conflicts of interest in the writing of this dissertation. Research has been carried out in accordance with the rules of the TU/e Code of Scientific Conduct. This is an independent dissertation, part of the research program Smart Cycling Futures with project number 438-15-160, which is partly financed by the Netherlands Organization for Scientific Research (NWO). Any opinions, findings, and conclusions or recommendations expressed in this report do not necessarily reflect the views of the founding parties.