STAFFORDSHIRE UNIVERSITY

Narratives of Digital Creep: An Investigation of the Socio-technical Transitions in Cycling

A thesis submitted in partial fulfilment of its requirement for the Degree of PhD

by

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Abstract

This thesis applies the conceptual language of practice theory to an investigation of the digital transitions occurring within the pursuit of cycling. Using a qualitative approach based on a series of semi-structured interviews, the research argues that cyclists' practices have, for many, become contingent on the presence of technology. The research asks what do the narratives and lifecycles of socio-technical practices tell us about the technologisation of leisure and what are the mechanisms and consequences of this change? It then explores what the implications mean for the culture and practices of cycling and also for health and active leisure/transport.

The complex narratives of cyclists formed amidst their mobile practices and digital counterparts provided evidence of digital creep. The pursuit of cycling has been altered through scripts found in applications like Strava – scripts embedded in applications become scripts embedded in the mind of cyclists and their practices. Gamification augments their experiences in a playful but also serious manner. The inherent self and social surveillance of online ride sharing elicits feelings of anxiety, pressure, and accountability.

The empirical discussions detail how cyclists' practices have become (co)produced through digital technologies. The research contends that cycling practitioners are part of and enmeshed within socio-technical cycling assemblages in which they have become imbued with a digital imperative. This digital consciousness derived from self-surveillance, gamified software scripts, and self-quantification leads to compulsions to ride and the formation of new habits and routines. Building upon theoretical work within digital geographies, this thesis provides further insight into the digitisation of leisure practices. It concludes by arguing that although scripted applications produce long-term sustained changes to practices, they raise moral and ethical considerations that need to be addressed to ensure disparities are not furthered. Finally, the research provides relevant applications for future health and environmental interventions.

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Chapter 1: Introduction

1.1 Research focus and context

> “When the spirits are low, when the day appears dark, when work becomes monotonous, when hope hardly seems worth having, just mount a bicycle and go out for a spin down the road, without a thought on anything but the ride you are taking” (Doyle, 1896: 38)

Cycling, for many, is a pursuit that has brought them freedom from their first experience of learning to ride as a child to a break from the stresses of modern-day life Doyle so eloquently captures. The act of cycling has changed since this quote was inscribed in Scientific American and has become a practice mediated through the use of technology. Despite cycling being more technologically mediated at its core, it is still an act of escapism, a time to explore and experience outdoor physical spaces and environments.

The practices of everyday life have become increasingly mediated through technology; this is particularly evident with its increasing integration into the pursuit of leisure practices (Thrift and French, 2002; Butryn and Masucci, 2009; Redhead, 2016; Barratt, 2017). Cyclists have been particularly proactive in their uptake and engagement with technology. In their pursuit of the sport, cyclists use a number of devices, notably GPS-enabled devices (and/or smartphones), to log their rides, train smarter, and share their accomplishments through associated online social ride-tracking applications like Strava. Applications like Strava are specifically designed around the needs of individuals engaged in sports like cycling, running, swimming, and walking. These applications share similarities with other forms of social media, providing users with a landscape of online social interactions between like-minded individuals. The prevalence of social media as a means of connecting virtually with friends has allowed specific sports-associated applications like Strava to become embedded within the digital practices of cyclists. Not only do such applications allow cyclists to keep digital records of their rides, but they also augment and enhance the experiences pre-, during, and post-ride.

This is achieved through scripts of code built into the applications that rely on aspects of gamification that can choreograph users' interactions with the physical environments (Barratt, 2017; Sailer *et al.,* 2013) and increase participation.

Motivation is a driving force for participation in leisure activities. Participation in cycling and other active leisure pursuits are found to have positive impacts on life satisfaction and subjective perceptions of well-being (Xu, Yuan, and Li, 2019). While there is substantive research into the psychological and sociological factors that play important roles within the inherent motivations to partake in active leisure pursuits (Chen and Pang, 2012), there is a distinct lack of empirical work (with the exception of Barratt 2017) into the impact that technology has had on cycling and wider active leisure pursuits. The insights into these digital interactions can further elucidate the geographical implications technology has had on everyday practices since the digital turn (Ash, Kitchin, and Leszczynski, 2016).

Scholarly research into the digital turn considers the digital as both subject and object within the research (Ash, Kitchin, and Leszczynski, 2019). This thesis, therefore, considers how digital technology (re)shapes, (re)configures, and mediates the production of space (Shove, Pantzar, and Watson, 2012) and the subsequent influences on the practices and experiences of cyclists (Ash, Kitchin, Leszczynski, 2019). As theorised by Thrift and French (2002), the production of space is inherently digital. Contemporary life is increasingly conducted through online spaces, and digital interactions increasingly transect various aspects of daily life. The pervasiveness of technology is experienced in mundane places like supermarkets, airports, leisure facilities, and universities. Lived experiences can be enhanced by the presence of technology, but in some instances, functionality is removed as technology fails (Kitchin and Dodge, 2011). Theories of digital technologies, such as Kitchin and Dodge's (2011) conceptualisation of 'code/space', are explored further within chapter 4 (section 4.4). The presence of the digital has become subsumed into the very practices that make up modern, everyday life – and it is through the lens of practices and practice theory that this research is conducted (Ash, Kitchin, and Leszczynski, 2019; Shove, Pantzar, and Watson, 2012).

In an era of accelerated digital growth, Millington (2018) theorised the transition of fitness pursuits into a new fitness boom termed Fitness 2.0. Building upon Millington (2018) and the work of Barratt (2017), the research focuses on developing an understanding of the digitally mediated practices of cyclists. This thesis will expand upon the idea that by using technology, cyclists are imbued with a ‘digital imperative’ (Barratt, 2017), a quasi-digital consciousness that results in compulsions to ride more frequently and participate in self-surveillance and self-quantification (Lupton, 2017). Through this, the research seeks to explain the links formed through each subsequent performance with technology and the connections that are (co)produced and (co)evolve before, during, and after practitioners’ rides have taken place. Later empirical and discussion chapters explore how such digital technologies and applications have wider applications to understanding other digitally mediated active leisure pursuits. These understandings could be utilised to encourage participation in active leisure and transportation, not only cycling but also walking and running (Department for Transport, 2017). The result is research that is relevant to future health and environmental policy.

The research is underpinned by practice theory, which provides a conceptual framework for understanding and thinking through the increasingly digital practices of cyclists. Theories of practice will provide a robust and flexible approach during the later empirical and discussion chapters. This flexibility is important to the research as it allows the nuanced and, at times, contradictory accounts of cyclists’ technologised interactions and practices to be fully represented and accounted for. Practice theory also provides an analytical understanding of the changes that have occurred with cyclists, highlighting their (co)evolution with technology and allowing insight into how human agency is altered by their inanimate objects (Dougherty, 2004; Ortner, 2006). Applications of practice theory allow the thesis to specifically examine how people, technology, space, and practices (co)evolve (Shove and Walker, 2010; Hand, Shove, And Southerton, 2005; 2007) and how technology subsequently becomes subsumed into practices (Eden, 2016).

As a result, this study intends to investigate how the practices of cyclists have changed. Specifically focusing on their technological mediation and the effects of or on their spatial experiences. It will explore how their rides are (co)produced through a network of digital technologies and applications that affect each subsequent performance. Digital technologies are increasingly present in other facets of everyday life (Redhead, 2016). It is through the medium of cycling that these technologised practices are examined in order to understand what capacity technology has to elicit sustained changes to practices that are applicable to wider everyday leisure practices. This thesis builds upon a wider body of research exploring the interconnectedness of humans and their digital counterparts (smartphones, applications, and dedicated GPS devices) that is becoming increasingly important as society continues to become more reliant on technology (see Michael, 2000, 2009; Butryn and Masucci, 2009; Barratt, 2017; Ash, Kitchin, and Leszczynski, 2019). Throughout the research, cyclists will be referred to as socio-technical assemblages. In referring to cyclists as socio-technical assemblages, it highlights how humans, technology, applications, and scripts are contingent on and influence the practices they participate in or are enmeshed with (Shove, Pantzar, and Watson, 2012; Kitchin, 2017).

Cycling has had a rich and varied history, particularly in the UK. With the progression of transport policy in the UK becoming increasingly car-centric, there has been a distinct lack of provision of cycling infrastructure development in many British cities - cyclists are few and far between as well as side-lined (Vigar, 2002; Cahill, 2010; Goldbluff and Aldred, 2011; Aldred, 2012). Such policies saw the development of towns and cities focusing on pedestrianised zones and improvements to the flow of cars in, out, and around the town or city, without consideration for cycling (Aldred, 2012). Between 1945 and 1975, cycling was largely excluded from transport policy, which led to a rapid decline in participation in leisure and transport (Cahill, 2010). Recently, cycling has become important amongst contemporary research and policy due to its benefits to health and the environment – action, infrastructure, and participation have yet to catch up with the pro-cycling rhetoric (Goldbluff and Aldred, 2011; Aldred, 2012).

In addition to the contemporary interest in cycling as a sustainable form of transport (Pucher and Buehler, 2017), the UK has seen significant growth in cycling participation. Between 2012 and 2015, the UK saw 100,000 more people cycling at least once per week (British Cycling, 2015). These increases have been attributed to the cycling success of Great Britain in the 2012 Olympics and Bradley Wiggins' victory at the Tour de France (Laker, 2013). Sport England's Active Lives Survey (2022) saw participation in cycling peak to 7.3 million active participants during 2020 (an increase of 1.3 million the previous year); however, there was a decline to 6.5 million throughout 2021. The Department for Transport (2021) note that this increase in participation is due to the decrease in motor vehicle traffic experienced due to the COVID-19 lockdowns. There are various reported benefits of cycling to both health and the environment. Cycling either for leisure or commuting reduces the risk of mortality in that person by 40 per cent (Hendriksen *et al.,* 2010); it has also been reported that investment in cycling reduces the need and cost of healthcare provision by the NHS (Burgess, 2013), and participation by older adults increases mobility and well-being (O'hern and Oxley, 2015)

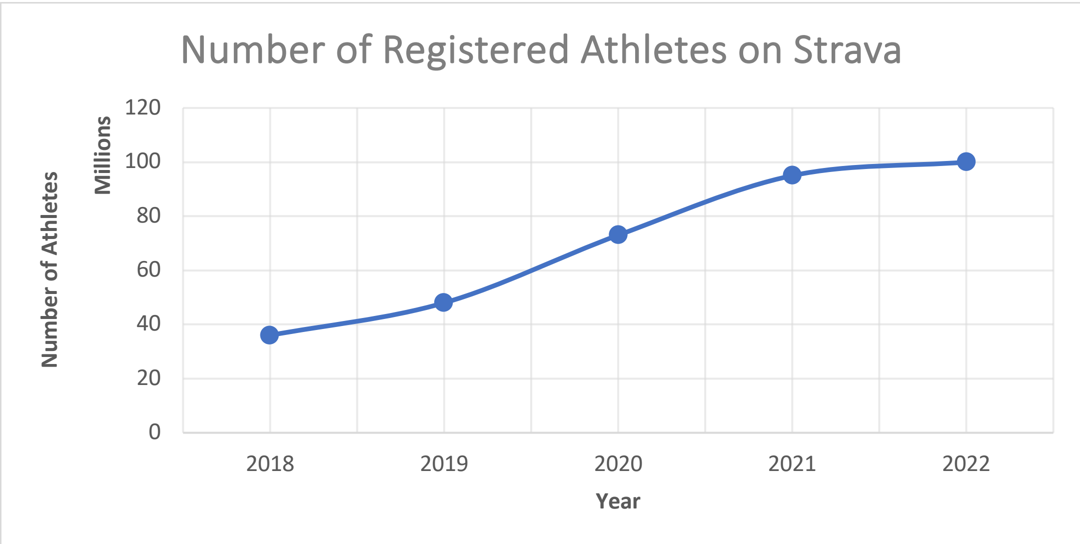


Figure 1.1 Graph showing registered athletes to Strava 2018 - 2022 (Strava, 2022b).

Figure 1.1 shows the number of registered users to Strava globally. As of 2022, Strava has surpassed 100 million users on its platform and is one of the most popular cycle logging applications. Technology is playing an increasingly important role in the practices of cyclists. Therefore, understanding the role technology and applications like Strava have within cyclists' practices is of contemporary importance. This research will not only provide context on the practices of already engaged cyclists but also identify avenues that future research and policy initiatives can utilise to encourage users to take part in active leisure and transport.

1.2 Research Questions

In order to explore the digital narratives and practices of cyclists, this thesis examines the pursuit of cycling utilising a practice theory approach. The sample of cyclists used within this study (see Chapter 5) are based in Great Britain. The findings relate to the British cycling context. The theoretical and empirical investigation explores the use of digital technologies and applications through three research questions:

1. What do the narratives and lifecycles of socio-technological practices tell us about the technologisation of leisure practices?

The purpose of this question is to explore how cyclists' technological practices evolve through their use. It seeks to understand how their experiential journey develops over time and how cyclists become recruited into socio-technical practices. It asks how cyclists' routines develop and change, exploring how cyclists' practices shift from ride-tracking to actively engaging with real-time data and virtual competitions in digitally enlivened lived spaces.

2. How do cyclists' practices change: what are the mechanisms of this change, and what are the consequences?

By understanding how technology is used pre-, during, and post-rides, this question seeks to understand the developmental nature of practices, what causes them to change, and what the consequences are. This question explores how the user feels because of the technology, their reasoning behind using it, and what effects it has had on their cycling.

3. What are the implications of these changes in cycling on its growing role in active leisure and transport, and what are the wider lessons with respect to the pursuit of leisure and everyday life?

The empirical findings from research questions one and two discuss the dynamics of the socio-technical changes identified in cyclists and how we can replicate the beneficial traits to promote health and well-being. As a result, research question three is pertinent to the discussion of digital technologies and how they are used to increase participation in cycling for active leisure and transport, as well as the motivational changes that occur to the practices of cyclists. For context, this question has highlighted certain aspects of digital interactions and narratives of cyclists that are transferable to other forms of daily leisure practices and active transport.

1.3 Structure of the Thesis

The following chapters provide the thesis with a contextual understanding of cycling as a contemporary practice and the socio-technical developments throughout its history. Chapter 2 introduces the pursuit of cycling by exploring its wider contexts. Aside from the people who take part in the act, cycling is made up of a wider network of technology, applications, organisations, books, and the various places in which the sport is enacted. This chapter highlights the complexity of cycling as a sport by guiding the reader through the various sub-disciplines and defining the key features and terms that become integral parts of the arguments formed within the empirical chapters presented later in the thesis. Cycling is a pursuit with a rich and varied history, which is outlined in Chapter 3. This historical account of the socio-technical developments in cycling presents cyclists as a group of people who have been engaged in technological developments throughout history. These historical pursuits inform the practices of cyclists with technology and the inherent need for self-quantification.

Chapter 4 introduces the theoretical frameworks that have been employed throughout the thesis, particularly within the empirical chapters, and supports the narratives provided by the participants. This chapter outlines how theories of social practice outlined by Reckwitz (2002), Schatzki (2002), and Shove, Pantzar, and Watson (2012) have allowed geographers and sociologists to understand the dynamics of social life. Practice theory allows scholars to understand how societal change occurs and how such changes persist. After exploring the theories of social practice, this chapter examines the Digital Turn within geography. The Digital Turn explores the blurring of digital and physical spaces. The digital turn, particularly within geography, explores how experiences of physical spaces are increasingly mediated through digital technology. Practice theory and digital geography form the theoretical framework on which this study has been based and help elucidate the information provided by participants in the empirical discussions. This chapter also reviews the limited research on socio-technical developments in cycling and the relevance of this study.

In Chapter 5, the methodological approach is used to explore narratives of digital creep within cycling. This outlines the different methods used within the research process. Semi-structured interviews provided the thesis with rich qualitative data that explored the experiences of cyclists and their technology. This chapter also outlines the researcher's positionality and reflects upon their own experiences as both a cyclist and researcher in order to understand the dynamics between participant and researcher. The sampling strategy is also outlined, along with practical issues that arose during the data collection and the strategies employed to overcome them.

Chapter 6 presents the empirical research. This empirical chapter is segmented into thematic sections that explore the narratives of digital creep and understanding the experiential journeys of cyclists. It examines how cyclists are recruited into socio-technical practices, how these technological practices change, and the consequences these changes have. The segmented nature of this chapter allows the research to present the complex, nuanced, and sometimes contradictory experiences of cyclists in a more structured manner. There are three segments that explore the production of technologically mediated cyclists and their practices: the production of cyclists, the technological mediation of cyclists, and the digital cyclist.

Chapter 7 builds upon the empirical discussion in the previous chapter and presents how digitally mediated interactions of cycling can be applied to other forms of active leisure and transport. Cyclists and cycling practices have been used as a case study to understand how technology has increased participation in the pursuit and encourages users to become more active. The discussions within this chapter show how the technologies used by cyclists can be transferred not only to other sports but can also be utilised to promote the benefits of exercise to people's health and well-being. Something which has become more evident with recent events like the COVID-19 pandemic, which occurred during the pursuit of this thesis. This chapter is a pertinent discussion on increasing the uptake of daily leisure practices.

Chapter 8, the conclusion, provides a summary of the main findings and contributions of the research. This chapter is the culmination of the research in relation to the initial research questions. Cyclists are considered once more as socio-technical assemblages in which the technology has become integral to cycling and subsumed within its practices. Technology alters the corporeal experience of cycling, transforming it from an ephemeral act into tangible digital artefacts ready to be experienced, analysed, and relived through companion technologies and applications. This chapter outlines the contributions to developing a theory of practice for exploring technological practices, as well as outlining the policy relevance of self-surveillance and self-quantification applications. It also outlines future considerations surrounding the ethical and moral implications that can limit leisure opportunities and exacerbate gender disparities. Finally, this chapter ends by introducing ideas for further research that have emerged from the empirical analysis of this research and can further develop an understanding of digitally mediated athletes.

Chapter 2: Contextualising cycling

2.1 Introduction

This chapter seeks to contextualise the various features of cycling in the UK. Contextualising the pursuit and its associated terms and technology enables an understanding of the socio-technical assemblages of cyclists and how and why technologically mediated practices have become established within. Throughout the research, cyclists will be conceptualised and referred to as socio-technical assemblages; this is in reference to assemblages as “a collection or gathering of things” (Oxford English Dictionary, 2010: 95). Its use throughout the thesis focuses the attention on the contributions of, and linkages between, different types of actors, concepts, and technological artefacts. However, to maintain assemblage, it is not used to refer to Assemblage Theory (DeLanda, 2006), which would cause tension with later applications of practice theory. By examining cyclists, their bikes, and their digital technologies as socio-technical assemblages, the research considers the influence of technology on the practice.

Cycling has moved beyond a biological and mechanical assemblage of the body and the bike and has returned with a new set of data assemblages. Lupton (2014b) considers the act of self-tracking, whereby users “knowingly and purposively collect information about themselves” (Lupton, 2016b: 2), as a type of data assemblage. She states that a "data assemblage is a complex socio-technical system composed of many actors whose central concern is the production of data" (Lupton, 2014b: 13). Cycling comprises people and technologies that form these assemblages. Cycling is predominantly enacted in outdoor spaces, although online virtual cycling applications are growing in popularity. The spaces in which people cycle can vary depending upon the sub-discipline of cycling they participate in; these spaces will be considered later in the chapter as the various sub-disciplines are outlined. Cycling has a rich heritage within the UK that cycling clubs and institutions like British Cycling and Cycling UK represent. This chapter seeks to contextualise the various facets of cycling in the UK. Doing so enables more profound insight into understanding how and why technologically mediated practices have become established within the socio-technical assemblages of cyclists. Before the research explores cyclists' narratives and socio-technical developments, this chapter provides a contextual overview of the pursuit of cycling. Instead of a glossary of terms, the various sub-disciplines, organisations, structures, and technologies will be explored below before the empirical research is explored later in the thesis. The chapter starts with an overview of cycling organisations in the UK, starting with their governing bodies and then introducing sub-disciplines, technologies, and terminologies.

2.2 Cycling in the UK

2.2.1 British Cycling

In 1959, the National Cyclists Union and the British League of Racing merged to form what is now known as British Cycling’. British Cycling has been responsible for ensuring that the rights and interests of cyclists and cycling are represented. The organisation's primary focus is to gather a large membership base and encourage increased participation in cycling. Membership of British Cycling surpassed 150,000 members in 2019 (British Cycling, 2019), and in its 2021 annual report, it aims to grow membership to 250,000 by 2024 (British Cycling, 2021). British Cycling has an appointed leadership team that runs the organisation nationally; members are encouraged to attend and take part in and attend regional meetings that feed directly into the national representation.

British Cycling oversees four broad categories of cycling and offers a number of resources for those looking to get involved, as well as information for those already involved. The categories are (British Cycling, 2022b):

1. Road Cycling
2. Off-Road Cycling
3. Track Cycling
4. Let’s Ride

British Cycling supports those participating in various cycling disciplines and club affiliations. This offers cycling clubs within the UK support for organisation, public liability insurance, and a suite of online tools to help with club management (British Cycling, 2022).

2.2.2 Cycling UK

Founded in 1878 as the Bicycle Touring Club, then as the Cyclists Touring Club, and now known as Cycling UK, they have been campaigning for the rights of cyclists for over 140 years (Cycling UK, 2022a). The focus of Cycling UK is through several campaign strategies aimed at improving cycling in the UK. This ranges from campaigns to make roads safer for cycling to widening access to off-road cycling trails and driver education and better cycling amenities on public transport (Cycling UK, 2022b). Cycling UK is a registered charity with over 70,000 members and is committed to making cycling mainstream.

2.2.3 Cycling clubs

Cycling clubs have a long history within the UK, with Peterborough Cycling Club being the oldest, founded in 1873. Peterborough Cycling Club (along with Oxford University (1873), Cambridge University (1874), Speedwell (1876) and Leek (1876) cycling clubs) predate the formation of the National Cyclists Union and Bicycle Touring Club. Club membership offers cyclists access to a community of individuals that operate as "a collective that shares the same goals and values" (Norcliffe, 2016: 133). Many established clubs within the UK operate organised events such as reliability rides, weekly rides, and even introductions to cycling. Although cycling is a sport that can be enacted alone, clubs facilitate an environment of knowledge dissemination from more experienced riders. During group rides, new cyclists can learn the skills and etiquette of cycling in large groups or join structured training rides and, in some clubs, join amateur racing teams. While cycling clubs remain a prominent fixture in cycling within the UK, information can increasingly be found through online channels and applications. It is worth noting, however, that while cycling clubs facilitate the forming of like-minded friendships, informal groups of cyclists also meet and ride regularly together.

2.3 Cyclists, kit, and terminologies

Cycling, to many, is a recreational pastime. A recent resurgence in the popularity of the pursuit has shed new contemporary light on the varied aspects of the sport as well as its importance for future policy developments. The practice of cycling can, at times, be considered complex due to the various sub-disciplines, technologies, and even terminologies. The following sections will explore the socio-technical assemblages (Lupton, 2014b) that enable cyclists in their pursuits and practices (Shove, Pantzar, and Watson, 2012). First, the various types of cycling will be explored. Following this, an overview of the technologies and kit that cyclists use will be introduced. Lastly, various terminologies associated with cycling will be defined.

2.3.1 Cycling and its sub-disciplines

There are several sub-disciplines found within cycling. Within these sub-disciplines, there are also even more niche specialisations within the pursuit. Each sub-discipline comes with varied technological innovations that enable and alter cyclists' engagement, pursuit, and practices. Despite the various types of cycling, participants often engage in several of the sub-disciplines, although usually, participants have a preference. While cycling can be divided into sub-disciplines and further specialisations, it is worth noting that specialisations within sub-disciplines often overlap. Cycling's sub-disciplines are outlined below:

1. Road Cycling: this takes place on paved and tarmacked surfaces around the UK. This is performed on 'road bikes', previously called 'racers' or 'race bikes'. ‘Time trialling’ is a more specialised variation of road cycling that sees participants use ‘time trial’ or ‘TT’ bikes. These bikes are designed to make the users as aerodynamic as possible. Time trialling is enacted over a specified distance (e.g. 5, 10, or 25 miles), and the time taken is recorded, the winner being the person to cover the distance in the shortest time.
2. Mountain Biking: this takes place in an off-road setting and can be found in ‘trail centres’ (such as Coed Y Brenin, where off-road cycle trails are

built specifically for the pursuit) or more rugged and wild environments (such as the Peak District National Park where cyclists can access green roads and bridleways, as well as create their own unofficial trails, though this is not encouraged). Mountain bikes often feature front and rear suspension systems that enable cyclists to ride more fluidly over the terrain by absorbing impacts from drops, rocks, and roots found along the way. More recently, specialisations can be found in the following:

   a. Downhill Mountain Biking: cyclists ride from the top of a hill down various artificial trails on bikes with large suspension components. Trails include obstacles like big jumps and large drops for the cyclist to navigate.
   b. Cyclocross: This is a cross-over of road cycling and mountain biking that sees participants use bikes that are more similar to road bikes, with some minor alterations: lower gears to help maintain traction on off-road routes and wider tyres with more grip.
   c. Gravel: This is often enacted on bridleways and green roads around the UK. The bikes used in this sport, like those used in cyclocross, are based on geometries similar to those used in road cycling. However, like cyclocross bikes, gravel bikes also incorporate lower gears, wider tyres, and, in some cases, some form of suspension.

3. Track cycling: there are many disciplines within track cycling that all entail various rules and regulations; however, it will be considered one for simplicity. Unlike road cycling and mountain biking, track cycling relies on specific locations. These locations are called 'velodromes' (defined as "a cycle-racing track, typically with steeply banked curves" (Oxford English Dictionary, 2010: 1,970)) and can be found both indoors and outdoors. Indoor velodromes are constructed from wood, while outdoor ones are made from tarmac or concrete. Track bikes are single-speed (one-gear) fixed-gear (a fixed-gear bike has no freewheel, which means as the back wheel spins, the pedals also turn) bikes that have no brakes.

Cycling within the UK also has a strong contingent of leisure cyclists. Along with this, there are a number of trails across the UK that facilitate traffic-free cycling on well-maintained trails. Many of these trails, such as the High Peak and Tissington Trails located in the Peak District National Park, offer bicycle hire and provide parking facilities and cafés. Amenities like these ensure that the trails are accessible regardless of age, physical abilities, and skill level. Trail centres also offer a cycling experience catered for different abilities. Often located within land owned by the Forestry Commission, they offer purpose-built trails, cycle hire, and other facilities like parking and cafés. Table 2.1 outlines the standard grading system used by trail centres in the UK. Although much of leisure cycling and those pursuing cycling more seriously can be covered by the sub-disciplines above, commuting is also growing in popularity. Research by Heinen, van Wee, and Maat (2010) concluded that socio-economic factors affect cycle commuting: those with a higher income commute by bike more frequently, while access to a car also reduces cycle commuting. Encouraging cycle commuting within the UK is of contemporary interest in academic debates, and several papers have been published in an attempt to increase and address the barriers to cycling (see Goodman and Aldred, 2018; Aldred, Croft, and Goodman, 2019; Aldred, 2014; Lovelace *et al.,* 2017; Pooley *et al.,* 2013).

Trail Grades	Suitability	Trail and Surface type	Gradients and Technical features	Suggested fitness level
Green – Easy	Beginner/novice cyclists. Basic bike skills are required. Most bikes and hybrids. Some green routes can take trailers.	The trail is relatively flat and wide. The surface may be loose, uneven, or muddy at times. It may include short, flowing singletrack sections.	Climbs and descents are primarily shallow—no challenging features.	Suitable for most people in good health.
Blue – Moderate	Intermediate cyclist/mountain biker with basic off-road riding skills. Mountain bikes or hybrids	As 'Green' plus specially constructed single track, the trail surface may include small roots and rock obstacles.	Most gradients are moderate but may include short, steep sections. Includes small Technical Trail Features (TTFs)	A good standard of fitness can help.
Red – Difficult	Proficient mountain bikers with good off-road riding skills. Suitable for better quality off-road mountain bikes.	It is steeper and tougher, mostly singletrack with technical sections. Expect variable surface types.	A wide range of challenging climbs and descents will be present. Expect boardwalks, berms, large rocks, medium steps, drop-offs, cambers, and water crossings.	Higher level of fitness and stamina.
Black - Severe	Expert mountain bike users who are used to physically demanding routes. Quality off-road mountain bikes.	As 'Red' but expecting more significant challenge and continuous difficulty, it can include any useable trail surface and may include exposed open hill sections.	Expect large, committing, and unavoidable TTFs. Sections will be challenging and variable, and it may also have 'downhill'- style sections.	Suitable for very active people used to prolonged effort.

Table 2.1 Trail grading system reproduced from British Cycling (British Cycling, 2022a).

2.3.2 Associated technologies of cycling

The historical socio-technical developments in cycling will be examined in detail in Chapter 3. Prior to this, this section seeks to provide context to the various modern technologies that are integral to modern-day cycling socio-technical assemblages, starting with bikes before moving to more specific technologies, devices, and applications. Outlining the various kit associated in this way will help with later understanding of the narratives held within the empirical and discussion chapters. While the chapter has highlighted the various sub-disciplines found within cycling, road cycling and mountain biking will be the focus of the remainder of the chapter due to these being not only the focus of the research but the main preferences of the research participants.

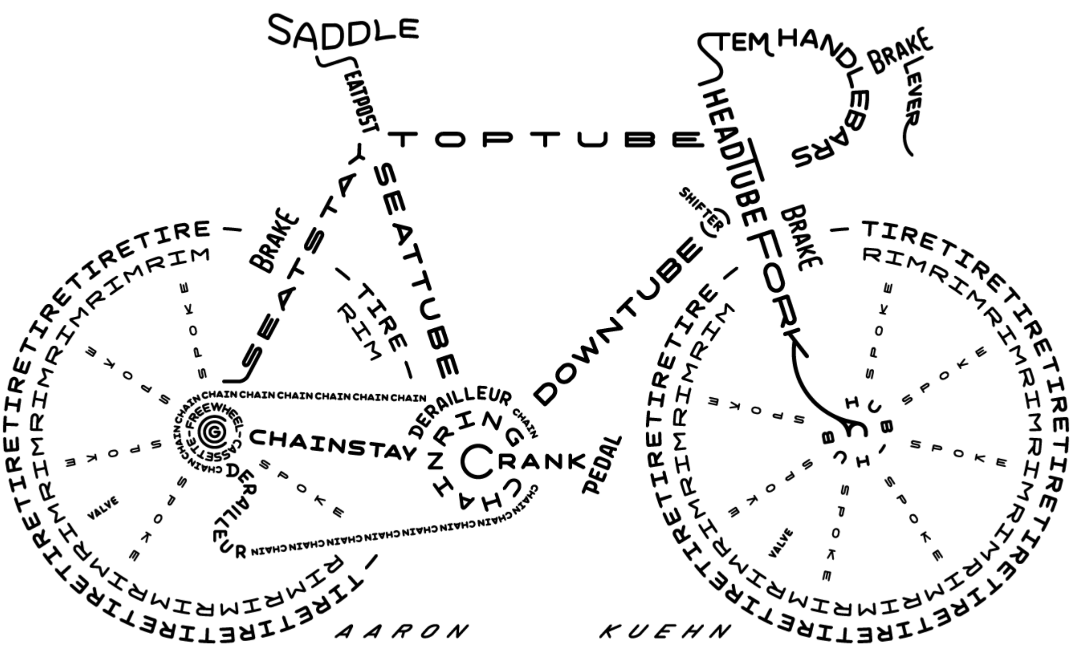


Figure 2.1 Bicycle typogram (Kuehn, 2010).

Road cycling is the most popular preference of the participants interviewed, with 30 of the 38 respondents stating it as their preference. Although the bicycles used in road cycling have received numerous technological advancements over the years, they can be considered most comparable to the

Rover (Section 3.2). The modern road bike is a complex piece of technology comprised of various intricate technologies designed to help cyclists ride faster, comfortably, and as efficiently as possible. Figure 2.1 is a typogram designed by artist Aaron Kuehn in 2010 that shows the various constituent parts of a modern-day road bike. However, one difference from this typogram is that modern bicycles have their gear shifters situated next to the brake lever (or, in some cases, built directly into the brake lever itself). Much of the technology found within modern bicycles can be considered as mundane (Michael, 2000). Although there are still attempts to reinvent the wheel (the debates between tubular wheelsets that do not require an inner tube and clincher wheelsets that do require an inner tube), much of the constituent parts of bikes have largely stayed the same. There are varied materials used in the design of bikes, ranging from steel, aluminium, carbon fibre, and bamboo, with aluminium and carbon fibre being the most popular. The bike itself is the most contingent part of the practice; without it, the practice cannot be enacted.

A particularly mundane part of a bicycle is the pedal. The pedal allows the cyclist to transfer their kinetic energy through the pedal, down the crank, into the drive train (consisting of the chainrings, chain, and cassette made up of cogs attached to the back wheel) and propel the bike forward. There are a wide variety of pedal interfaces available to suit various riding disciplines. The most familiar design is a platform pedal (also called 'flat pedal' or 'flats'), whereby the foot is placed on top of the pedal itself. Further to this is a range of pedals called 'clipless' pedals (see Figure 2.2). Despite being named 'clipless', the foot is clipped into the pedal by a 'cleat' attached to the bottom of a specific cycling shoe. The name 'clipless' was used to differentiate this new type of pedal from its predecessor, which was attached to platform-style pedals. This previous style formed a cage around the foot, and a strap was used to secure it further to the pedal. The design benefit of clipless pedals meant that taking the foot off the pedal required a singular step rather than a two-step process. Along with this, the cyclist's feet would become free in the event of a crash or an accident. The benefit of being attached to pedals meant that cyclists could recruit their muscles in the entirety of the pedal stroke, resulting in a more efficient effort (utilising the push down of one leg and the pull up of the other) (Friel, 2009).

Figure 2.1 Different pedal types (Dedhambike, 2022).

Figure 2.2 A heart rate monitor chest strap.

Figure 2.3 Stages crank-based power meters (Stages Cycling, 2022).

There have also been developments that allow cyclists to quantify their cycling performances, which will be discussed further in section 3.3. These technologies are not contingent on the pursuit of cycling; however, as will become apparent through the narratives of cyclists, they have profound effects on their experiences. Figures 2.3 and 2.4 show two such innovations in quantification that transform bodily functions into known data points displayed on a connected bicycle computer (dedicated GPS device), as shown in Figure 2.5. Cyclists with these technologies become an entity engaged and armed with Lupton's (2014b: 12) definition of data assemblage whereby their "bodies are increasingly digitised in a multitude of ways".

Figure 2.4 Dedicated GPS device Garmin Edge 520.

There are several dedicated GPS devices on the market. The core functionality of the devices is very similar; however, some offer slight differences. Manufacturers also produce devices that offer additional functionality, such as onboard maps, route design, and turn-by-turn directions. While no clear best dedicated GPS devices exist, much contention exists about users' preferences within the cycling community. The most popular manufacturers are listed below:

1. Garmin
2. Wahoo
3. Hammerhead
4. SRM
5. Cateye
6. Polar

Along with the quantification of cycling, a number of associated ride-logging applications offer cyclists a plethora of tools to aid in the self-surveillance of their bodily functions. Some of these applications, like Map My Ride, Strava, and Komoot, can record users' rides via a smartphone application. In contrast, other users upload files from dedicated GPS devices to elicit greater analysis. Popular applications include:

1. Strava: The most popular application amongst cyclists, it can be used via a smartphone app or uploaded files from dedicated GPS devices. Users can plan routes, compete in online leaderboards, set goals, and analyse their training metrics from one application.
2. Map My Ride: one of the first applications to record users' bike rides via smartphone apps; however, it used significant battery power.
3. Komoot: is a sophisticated mapping application that focuses on the creation and dissemination of routes for users to enjoy and repeat. It provides users with detailed information about routes.
4. Training Peaks: is a software tool for individuals and coaches to design specific training plans. It also provides rich and deep data analysis for sensors like Power and Heart rate.
5. Veloviewer: provides users with new insights and graphics based on their Strava activities. It can also provide an in-depth analysis of Strava segments.

6. Ride with GPS: is a tool for planning routes and downloading relevant files onto dedicated GPS devices for turn-by-turn directions. It also includes an associated application for recording rides.
7. Garmin Connect: is an application used in conjunction with Garmin GPS devices. Activities are uploaded through Garmin Connect to other applications like Strava. Although it provides detailed analysis, it predominantly connects to Strava.
8. Zwift: is a virtual cycling platform that transforms indoor spaces like garages or living rooms into cycling spaces. Users connect smart indoor bike trainers (commonly known as turbo trainers) to the application and ride along while a digital avatar navigates virtual landscapes.

While not an exhaustive list, this provides an overview of the popular applications within the sport and their uses. This section has highlighted the various technologies cyclists employ that create and transform them into socio-technical assemblages.

2.3.3 Terminologies in Cycling

Language forms an integral part of written and spoken communication within everyday life. As with many other sports, cycling has developed an array of terminologies that refer to specific aspects of the sport. These terminologies can be referred to as sports jargon and, as Kowalikowa (2009: 63) states, serve to "fulfil their needs of communication in the areas of their sports activities". Jargon within cycling can refer to specific training, physical feelings, formations of cyclists, and specific aspects of cycle racing. Table 2.2 outlines some specific terms:

Term	Definition
Blown up	A cyclist experiencing fatigue or loss of energy can be caused by not consuming enough food and drink during the ride, resulting in the depletion of glycogen stores, also referred to as Bonk or Hitting the Wall.
Breakaway	A small group of riders that have successfully gotten away from the Peloton during a race.
Cadence	The rate at which the cyclists turn the pedals (displayed in revolutions per minute or rpm).
Chain-gang	A chain-gang is a group of cyclists who ride close together. During a chain-gang, cyclists take turns at the front of the group for a specified period of time before going to the back. Those not at the front conserve energy. It is a fast-paced and intense form of training, with cyclists maintaining high speeds for extended periods of time. It is also referred to as a chainy.
Climb	This refers to the act of riding uphill. Climbs can also be classified based on subjective elements. Category 4 is the easiest climb, and Category 1 is the hardest. There is, however, HC, which stands for *Hors Catégorie,* a French term that refers to a climb that is beyond categorisation because of its sheer difficulty.
Criterium	A race on a closed circuit, a short distance where racers do laps, is also known as a crit.
GPS	Global Positioning System – a network of satellites that provide real-time navigation. Many devices also utilise GLONASS (Russian satellite network) and GALILEO (European satellite network)
Fred	Used to describe a beginner cyclist.
Hammer	To ride as fast as possible
Intervals	A training term that refers to hard efforts followed by a period of rest. Intervals consist of specified time periods for both the effort and the rest.
King or Queen of the Mountain	The title is given to the best climber in a road race. Winners of the King of the Mountain receive a polka-dot jersey. The term also refers to the cyclist at the top of segment leaderboards on Strava.
MAMIL	Middle-aged man in Lycra. This is a reference to a popular demographic of cyclists and the type of attire cyclists typically wear.
Mechanical	An issue with the bike's mechanical parts, such as a broken wheel spoke or a snapped chain.
Peloton	This term refers to a group of cyclists riding close together, commonly seen in races like the Tour de France. Riding in a peloton shelters cyclists from the effects of the wind and results in energy savings.
Pull	To take the lead during a chain-gang.
Sportive	An organised cycling event in which cyclists follow a set route and distance. There are often stops along the route where cyclists can refill water bottles and get more food. These are paid events; however, they are not classed as a race.
Tempo	A steady pace, which is a level of exertion found just below a rider's anaerobic threshold, is often used as a reference for training purposes.
UCI	Union Cycliste Internationale. The UCI is the world governing body of cycling and competitive racing. It governs world tour races such as the Giro d'Italia, le Tour de France, and the Vuelta a España.

Table 2.2 Cycling-specific jargon.

2.4 Summary

This chapter has contextualised the pursuit of cycling. It has introduced the various sub-disciplines, explored the various technologies involved with cycling and cyclists, and provided an overview of some of the specific terminologies used within cycling. Some of the elements of such assemblages are contingent to the enactment of the sport itself. In contrast, others have become enmeshed within the practices (Shove, Pantzar, and Watson, 2012) due to the enhancement offered to cyclists. While the sections within this chapter do not fully capture the extent of technology involved in cycling, they help to situate the reader within a sport that continually seeks new ways to quantify performance and improve training.

The socio-technical assemblages outlined within this chapter add context to the various arrangements that cyclists take. However, as will be discovered in the empirical and discussion chapters later in the thesis, such assemblages are considered for the influences they have on the act of doing (Shove, Pantzar, and Watson, 2012). Each piece of technology has a meaning within the cyclist's socio-technical assemblage, and although dedicated GPS devices, heart rate monitors, and power meters are not integral to the enactment of cycling, the data they generate are contingent to the experience of the assemblage (Lupton, 2014b) as will be explored through the narratives of participants.

The following chapter outlines the historical development of cycling. It explores the socio-technical cycling assemblages that transformed the bicycle between 1817 and 1885. It also charts the development of cycling technology that, through socio-technical cycling assemblages and embodied practices, has transformed and (re)shaped self-quantification within cycling.

Chapter 3: Riding by numbers: the socio-technical development of cycling and ride quantification

3.1 Introduction

> "Think back to your first cycling experience, the moment you wobbled beyond the clutches of an anxious parent, without recourse to training wheels. Chances are, it rates as a highlight of childhood" (Herlihy, 2004: 1).

As Herlihy (2004) states, the bicycle is often a person's first experience of freedom and a turning point in one's childhood. The bike, for many people, has been a romantic endeavour, their first taste of freedom, a utilitarian means of cheap transportation, recreational adventure, and organised sporting events like the Tour de France. The bicycle has been through numerous iterations and technological developments throughout the late nineteenth and twentieth centuries that have culminated in the design of the modern-day bicycle.

The aim of this chapter is to investigate the legacy and impact of quantification and the progression of technology within the practices of cyclists. As technology and applications have become embedded within cycling culture, it is important to understand how and where these practices have become rooted within cycling. By looking at the historical accounts of cycling quantification, this chapter seeks to identify the foundations that have led to technology becoming an important aspect of contemporary cycling practices. This chapter looks at how the practices of cyclists have been (re)shaped throughout history and how the uptake of technologies has become normalised within cycling culture. As a result, this chapter is a key contribution to knowledge, as research on the changes to practices caused by the use of technology in leisure pursuits is still in its infancy (with the exception of Barratt, 2017; Boss *et al.,* 2018; Broach, Dill, and Gliebe; 2012). Looking at how technology has become entwined with the pursuit of cycling in the past will help the project and other contemporary scholars to have a clearer understanding of how socio-technical practices emerge, endure, and die (Shove, Pantzar, and Watson, 2012). This will show how technologies and the practices that they (co)create become normalised and adopted more widely by cycling practitioners.

In cycling's recent history, digital technologies have started to blur the lines between digital and physical experiences. Digital technologies have themselves been the product of much development and innovation. Global positioning system (GPS) technologies have become prevalent in everyday life, facilitating new forms of navigation (Verhoeff, 2012). This emergence of GPS-enabled technologies has also become an integral part of sporting technology. These GPS-enabled devices also contain technology and sensors that allow users to analyse an array of data metrics, from speed, distance, and elevation gain to biological data such as heart rate and power (Lupton, 2016a; Millington, 2018). The development of cycling computers has facilitated the emergence of other associated devices and applications (Shove and Southerton, 2000). Applications such as Strava allow users to plot their routes, compare previous personal efforts, and compete against themselves or friends through virtual challenges and online leaderboards (Barratt, 2017). As the previous chapter outlined and contextualised the pursuit of cycling, this chapter seeks to identify the humble beginnings of quantifying leisure and sport, particularly cycling. Throughout the years, cyclists have pushed barriers through arduous races such as le Tour de France and distance records such as the most miles in a year and the fastest time to cycle 100,000 miles.

As a result of such efforts, cyclists have often sought out ways to quantify their practices; this has developed over time from rudimentary wheel-mounted rivet-based mile-o-meters to modern-day sophisticated dedicated GPS devices, power meters, and digital bodily implants. The following sections serve to set out some of the key moments in the historical socio-technical developments within cycling. It begins by looking at the development of the bicycle. The purpose of this is to situate the bicycle itself as a socio-technical device that has been (re)shaped over time as cyclists' practices have (co)evolved with its use. Following the development of the bicycle, the chapter then delineates the quantification of cycling throughout history. Quantification in cycling has taken many forms throughout history, from paper journals of cycling clubs and record attempts to rudimentary spoke-mounted mile trackers and sophisticated dedicated GPS devices.

3.2 The socio-technical development of the bicycle

Cycling and the technology that enables it should not be seen as a purely technological endeavour driven solely by engineers and technologists. The development of technology is as much a social process as it is technological (Bijker, 1995; Law, 2002; Shove, Pantzar, and Watson, 2012). Technological developments are driven by a need or a want, along with how practitioners use such technologies within their practices and the places where the practice is undertaken – often, through practice, technology can take on a new purpose, changing the course of its subsequent technological developments. Therefore, the development of the bicycle and, more recently, the devices that facilitate self-quantification, the practice of tracking and analysing personal data (particularly health and wellbeing), cannot be considered in isolation from the practice.

For many, thinking of a bicycle would conjure an image of a diamond-like shape made of two triangles and two equally sized wheels, with the rear driven by a chain, cranks, and cogs (see Figure 2.1). However, this design was the product of various iterations and developments from early pioneers and mechanics in pursuit of a machine to transport humans under their own power without the use of horses (Herlihy, 2004). For many years, there has been implicit technology surrounding the development of the modern bicycle; instead of neat linearity in the history of its development, the bicycle has been (re)shaped through various designs (Bijker, 1995). Linear progression is often applied with hindsight to distinguish principles that were successfully adopted into current and mainstream iterations of bicycle production. The work of Wiebe Bijker (a social science and technology researcher and academic) and David Herlihy (an author and historian) provided detailed accounts of the technological and social developments of the bicycle that inform socio-technical investigations discussed within the following paragraphs.

In 1817, Karl Drais produced the first human-powered carriage (Figure 3.1). It took the form of two equally sized iron carriage wheels connected by a wooden perch, with a rest for the forearms. The design was called the 'Lauf-Maschine' (running machine), soon to be known as the '*Draisienne'* or *'Velocipede'.* The design allowed users to propel themselves by running and, in the early designs, steer by using the bar that the forearms rested on. However, Drais later improved on this design with steering done by a wooden handle positioned in front of the resting bar (Bijker, 1995; Herlihy, 2004). Drais' running machine did well in terms of its popularity. He built and sold a number of them under a patent he acquired. Along with this, the running machine became recognised as a road vehicle (Bijker, 1995). While the running machine saw some success in Germany, England, and France, it was somewhat limited by its own design. Firstly, without brakes, the 'Draisienne' was dangerous, particularly when going downhill. Secondly, the manoeuvrability of the machine was difficult to undertake; as well as this, the machine's primitive design had a distinct lack of comfort with the body shifting and straining as it bumped over uneven ground, leading to several injuries (Bijker, 1995).

Figure 3.1 Karl Drais' Driasienne or running machine (Source: lesdraisiennes.fr)

Although Karl Drais' running machine saw some success, it was soon dismissed, and the search for a practical mechanical human-powered machine continued. The search for such a machine went on for some decades, particularly in Britain, which had very little success; it was not until 1867 that Le Moniteur Universel du Soir, a newspaper in France, published an advertisement for "pedal velocipedes" constructed by Pierre Michaux (Herlihy, 2004). Michaux improved upon the running machine largely constructed of iron; they bore a large front wheel with cranks attached directly to the front hub (Wilson, 1973; Herlihy, 2004). Michaux's velocipede solved some of the issues of the running machine; firstly, the leather saddle was mounted atop an iron spring to cushion any shock from the road. There was also the ability to stop the bike either by pedalling backwards or, on more expensive models, by twisting an end of the handlebar to apply a brake to the rear wheel (Herlihy, 2004). Further developments to Michaux's design continued, most notably in England, where the front wheel was enlarged to achieve an increase in speed "while maintaining the same angular velocity" (Bijker, 1995: 30). As a result of Michaux's developments, the term bicycle was coined to refer to a crank driven two-wheeled machine.

The pursuit of speed spurred on the high-wheeled era of bicycles. Though Michaux's creation was popular and at its height, producing 400 machines a year between 1867 and 1869, its popularity eventually waned; there was a small community that was devoted to improving and developing the velocipede, now more commonly referred to as the bicycle (Wilson, 1973; Herlihy, 2004). One improvement was the development of increasing the wheel diameter. Instead of rigid spokes like those of carriage wheels, wire spokes that were under tension allowed wheels to get larger and remain light in comparison to their size (Bijker, 1995). It was 1870 when the patent for the first 'high-wheeled ordinary bicycle' was awarded to Starley and Hillman (Wilson, 1973). Although previous designs were fascinating to various populations, using such machines as a form of viable transport practice was not integrated into daily life (Shove, Pantzar, and Watson, 2012). Unlike skiing, the trend of bicycling began as a sport that eventually transitioned into a form of utilitarian transportation. This was thanks largely in part to the sport's popularity. However, for those who adopted these early iterations of bicycles, their practices led to socio-technical developments in the pursuit of cycling (Shove, Pantzar, and Watson, 2012). Many of these developments were in the pursuit of speed, where younger individuals used ever-increasing wheel diameters to travel faster (Bijker, 1995; Herlihy, 2004).

By the 1880s, developments of the high-wheeled ordinary bicycle soon plateaued, and although its popularity led to many technical developments, its flaws began to become more evident. The most common safety concerns pertained to the height of these bicycles; one way to combat this was to lower the saddle. However, this caused more problems than it solved, and as a result, the search continued (Bijker, 1995). Before long, there was a new design on the scene, The Rover (Figure 3.2), showcased in 1885 (Wilson, 1973). This design consisted of a 36-inch front wheel with a chain to the smaller rear wheel. The gearing of the chain could be varied to account for what would previously be achieved by enlarging the front wheel (Bijker, 1995; Herlihy, 2004). The development of the Rover addressed many of the safety concerns that had become associated with current cycling practices. Starley's Rover featured an adjustable saddle that could be raised, lowered, and moved forward or backwards, along with adjustable handlebars to ensure the rider was in a more comfortable position (Herlihy, 2004). The Rover revolutionised cycling where once associations of danger were attached to previous designs, the Rover was imbued with notions of safety that allowed for the practice of cycling to become more widely adopted (Wilson, 1973; Herlihy, 2004; Shove and Pantzar, 2005).

Since the development of the Rover, changes to the bicycle have been relatively minor. Bicycles are still low to the ground; however, the overall design has stayed largely the same in recent years. Just as bike racing led to improvements in cycling technology of the past, the sport of cycling has, in recent years, introduced and led to the progression of not only bicycle technology but also the associated technologies (Herlihy, 2004). Furthermore, cycling has gone through a number of socio-technical transitions throughout its history. Early iterations saw cumbersome designs that did not become a popularised mode of transport (Wilson, 1973). Since then, bicycles have (co)evolved with the practices of their users; the pursuit of speed saw increasing wheel diameters. However, these developments led to safety concerns. By addressing these safety concerns, the bicycle took on new meanings as a viable means of mass transportation and leisure with the introduction of the Rover.

Figure 3.2 Starley's Rover Safety Bicycle (Online Bicycle Museum, 2022).

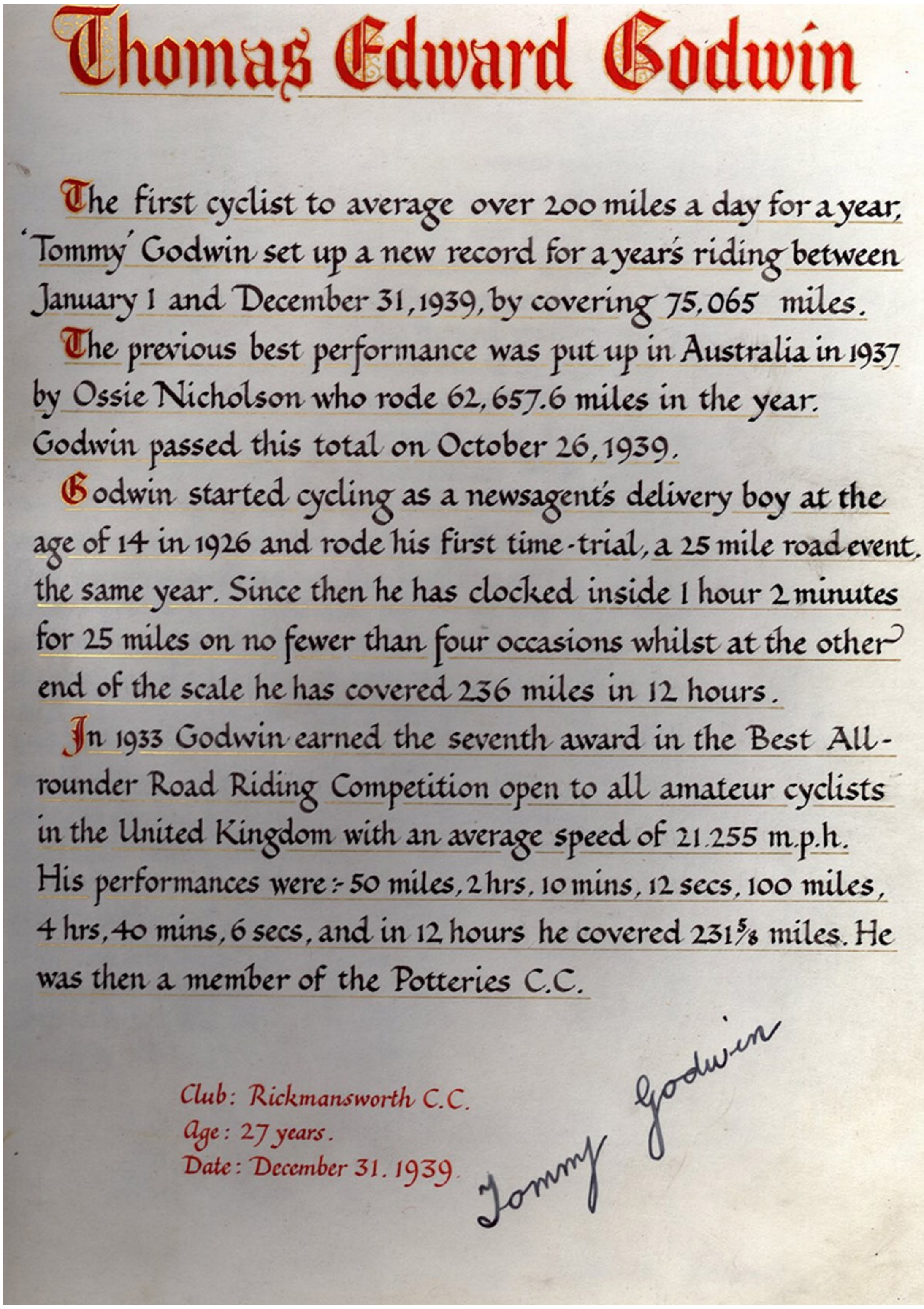
3.3 Socio-technological developments and quantification in cycling

Although modern-day bicycles still bear similarities to the Rover's original design, technology within the sport is still advancing. More recent technological developments within cycling have been the invention of clipless pedals, connecting the bicycle cranks to the feet of its rider, creating a human-machine hybrid. Much of these developments occur within the competitive field of professional cycling teams and companies at the forefront of cycling in the pursuit of technological advancements (Herlihy, 2004). This section explores the developments of cycling technologies used throughout history borne out of a fascination with distances covered, speeds achieved, and bodily performance (Fleishman, 2000).

3.3.1 Historical Achievements: Tommy Godwin

As previously discussed, the development of the bicycle occurred through various socio-technical needs, first the pursuit of speed, followed by the development of safety bicycles that provided mass utilitarian function. Early bicycles used large wheel diameters to increase their speeds. However, later developments saw the use of gearing and chain-driven back wheels to achieve the same outcome (Herlihy, 2004). In 1932, Cycling Magazine produced the Golden Book of Cycling. The purpose of the book was to recognise the outstanding achievements of cyclists and honour them within its pages. This resulted in the pursuit of cycling becoming entangled with the practice of self-quantification. Pages within the book have been dedicated to a number of cyclists and “tell of meritorious rides or series of rides in competition or against the clock on road or path” (The Golden Book of Cycling, 1932: n.p). Frank Southall became the first cyclist to become honoured within its pages and was awarded the title of Best British All-Rounder for individual time trials in 1932. He signed his entry into the book in front of 7,000 cyclists at the Royal Albert Hall. In 1972, the book closed its pages with its last entry honouring Hugh Porter for his achievement in cycle racing, which crossed a number of different cycling pursuits.

One entry within the book stands out as a significant achievement. On 31st December 1939, Thomas Edward Godwin (Tommy Godwin) was entered into the Golden Pages (Figure 3.3). Godwin had consistently ridden over 200 miles a day in pursuit of the greatest distance covered in a one-year period. The culmination of his cycling in 1939 meant that he had totalled 75,065 miles, beating the previous record holder (Australian Ossie Nicholson) by 12,408 miles. However, Godwin continued riding into 1940 and surpassed 100,000 miles in 500 days, setting yet another record for the fastest time in achieving that distance. Godwin's achievement is significant not only due to the distance he covered but also in the fact that his record stood for 75 years, only to be beaten in 2015 by a mere 1,011 miles.


Thomas Edward Godwin

The first cyclist to average over 200 miles a day for a year, 'Tommy' Godwin set up a new record for a year's riding between January 1 and December 31, 1939, by covering 75,065 miles.

The previous best performance was put up in Australia in 1937 by Ossie Nicholson who rode 62,657.6 miles in the year. Godwin passed this total on October 26, 1939.

Godwin started cycling as a newsagent's delivery boy at the age of 14 in 1926 and rode his first time-trial, a 25 mile road event, the same year. Since then he has clocked inside 1 hour 2 minutes for 25 miles on no fewer than four occasions whilst at the other end of the scale he has covered 236 miles in 12 hours.

In 1933 Godwin earned the seventh award in the Best All-rounder Road Riding Competition open to all amateur cyclists in the United Kingdom with an average speed of 21.255 m.p.h. His performances were :- 50 miles, 2 hrs, 10 mins, 12 secs, 100 miles, 4 hrs, 40 mins, 6 secs, and in 12 hours he covered 231⅝ miles. He was then a member of the Potteries C.C.

Club: Rickmansworth C.C.
Age: 27 years.
Date: December 31. 1939.

Tommy Godwin

Figure 3.3 Tommy Godwin's entry into the Golden Book of Cycling (The Pedal Club, 2022).

3.3.2 The cyclometer

Godwin's year record was an astounding achievement. To ratify the record, mileage cards were verified at the end of each day, signed and checked by witnesses, and numerous spot checks were conducted by the RAC. The RAC followed along to verify Godwin was, in fact, cycling the distances and speeds he claimed. Most notably, however, was that at the start of his record attempt, Godwin had a mile-o-meter mounted and sealed on his bike. This ensured that his mileage was accurate and trackable (Barter, 2011). The '*Cyclometer'* (as it was known by its inventor Curtis Veeder, see Figure 3.4) was invented in 1895 to measure the distance travelled by bike and marketed with the slogan "it's nice to know how far you go" (Asher, 2002: n.p; Veeder-Root, N.D.). This rudimentary device counted the revolutions of a wheel, rotating a mechanism within the device to display the distance on an analogue display to the user.

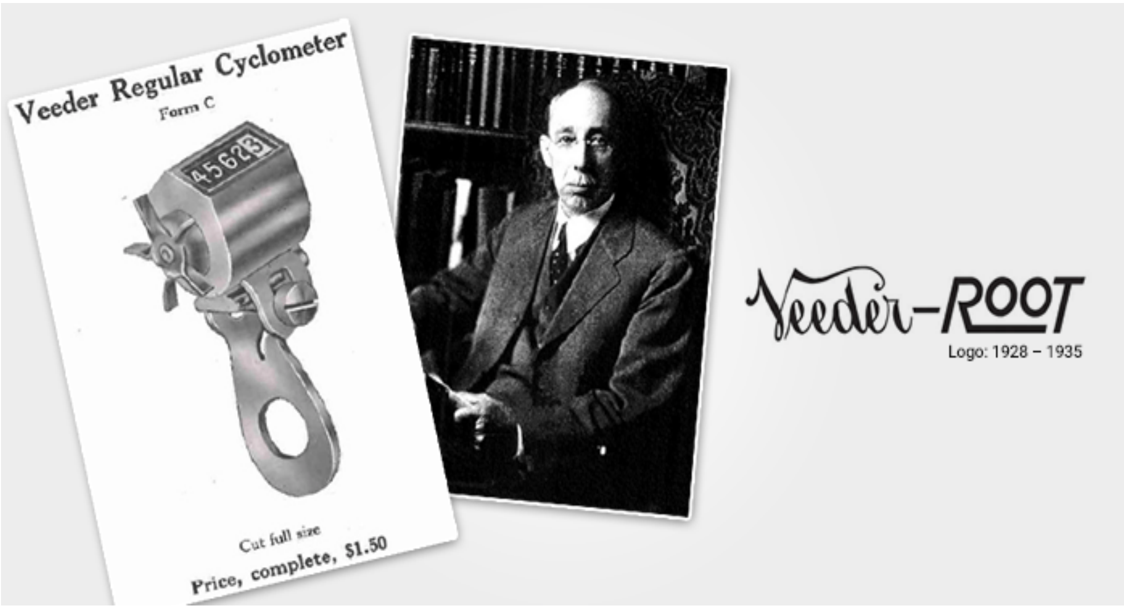


Figure 3.4 Veeder-Root Cyclometer. Invented in 1895 this was the first device used to track the distance travelled on a bicycle (Veeder-Root, N.D.).

Although the use of the cyclometer allowed cyclists to track how far they had ridden, this did not stop innovation. As knowing the distance travelled had been an important feature for many years there were later devices that could give readings of speed. Released in 1985, the Avocet Cyclometer 20 (Figure 3.5) had a basic head unit that could be mounted to the handlebars; a cable was used to connect the head unit to the receiver that was mounted at the base of the fork of the front wheel, and a transmitter attached to the hub of the bicycle wheel. This first rudimentary Cycle Computer had a one-line display that could give the rider an array of information. By calibrating the computer to the size of the wheel, the device was able to show the user the speed, trip distance, total distance, and timing of their rides (Avocet, 1985).

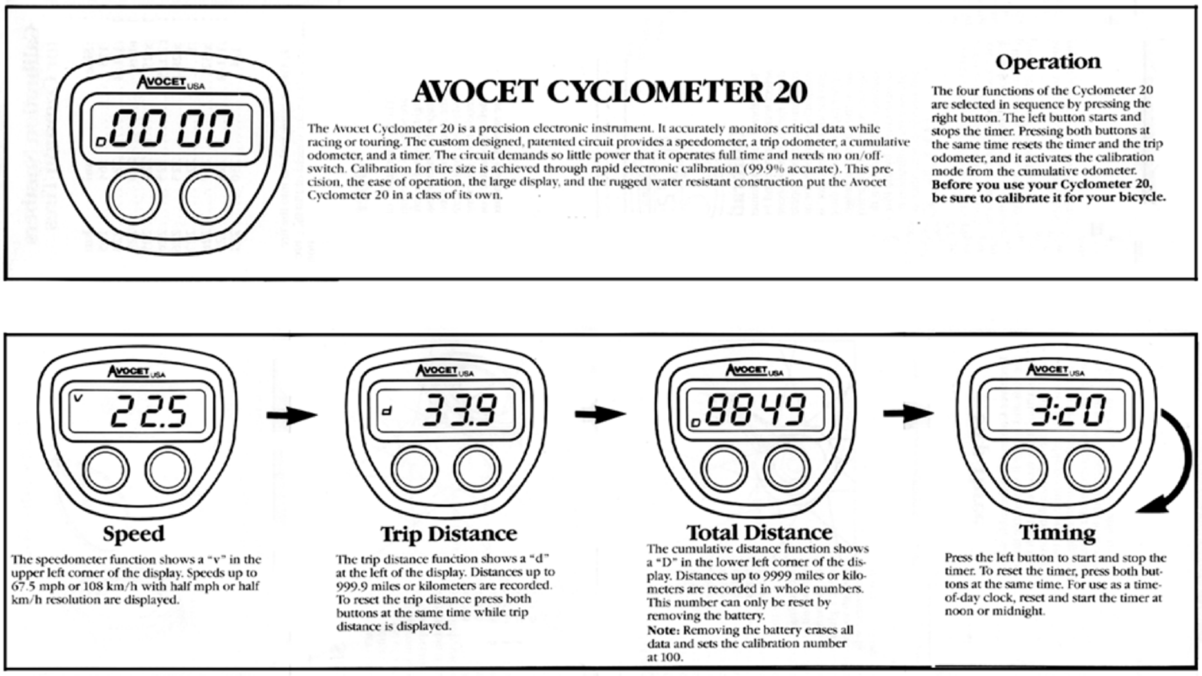


Figure 3.5 Avocet Cyclometer 20 Bike Computer (Avocet, N.D.).

3.3.3 The development of the cycle computer

With Avocet's release of the Cyclometer 20, the era of the cycle computer was born. These modern bike computers were not too dissimilar to the original Cyclometers designed in the late nineteenth century. Instead of a gear being turned by each revolution of the wheel, magnets were used. One is mounted to a spoke on the wheel, and a corresponding magnetic sensor is attached to the fork of the bike. While many cyclists would have no need or desire to know the distance they travelled down to the hundredth of a mile or the speed they travelled, the emergence of the Cyclocomputer was accompanied by a growing number of cyclists who were fervent advocates of this data revolution (Fleishman, 2000). Early iterations of these computers were limited to tracking speed and distance; however, it was not long until the addition of more sensors arrived. Of note is the addition of a magnet to the cranks of the bike and another receiving sensor close by to count the pedal revolutions of a cyclist, known within the pursuit as cadence. Avocet's Cyclometer 45tt was one of the first devices to use the cadence sensor.

The introduction of cadence sensors and cycle computers allowed cyclists to ride more accurately to determined rhythms and speeds. Cadence allowed cyclists to measure their effort in a more quantifiable way than before. Just as the larger wheels were developed in the pursuit of speed, bike computers like Avocet's allowed cyclists to see real-time data that can facilitate faster cycling (Mosley, 2010). Cadence allowed cyclists to ride according to data rather than feel (Friel, 2009). By keeping a higher cadence, i.e., the legs spinning more frequently, cyclists push a lower load strain and utilise their cardiovascular system more effectively; elite and professional cyclists have been observed to cycle with a cadence of 90 – 100 rpm (Friel, 2009). This, in turn, leads to lower strain on the muscles (Norman, 2021). Training with cadence has allowed coaches, professional athletes, and keen amateurs alike to determine how effectively they ride. Cyclists, particularly those who race and can pedal smoothly at a higher cadence, can negotiate turns quicker without wasting momentum. This allows cyclists to reduce their energy expenditure while maintaining higher physical outputs (Friel, 2009). Around a similar time to the release of Avocet Cycling computers and cadence sensors, there were some major developments occurring around heart rate, particularly in portable monitors for the Finnish National Cross Country Ski Team.

3.3.4 Cycling to a new beat

Electrocardiograph machines have been around for a long time; the units were big and cumbersome and not initially sought-after training aids. In 1977 Seppo Säynäjäkangas, a Finnish Professor, developed a battery-powered fingertip heart rate monitor for the Finnish National Cross Country Ski Team to use as a training aid (Kite-Powell, 2016). He later went on to found the company Polar Electro and released their first marketable wearable heart rate monitor in 1978. By 1984, the company had developed the Polar Sport Tester PE3000 (Figure 3.6) – a heart rate monitor with an integrated computer that allowed users to monitor and analyse their heart rate in real-time (Kite-Powell, 2016). The transmitter was attached to the chest by either disposable electrodes or an elasticated belt strap; the receiver was a basic wrist-mounted computer that displayed the current heart rate and time transmitted via a magnetic field (Laukkanen and Virtanen, 1998).

Figure 3.6 Polar Sport Tester PE3000 (Kite-Powell, 2016).

The production of Polar’s Sport Tester PE3000 started a new era of biological analysis within sport (Lea, 2019). Although initially, heart rate monitors were seen primarily as a gimmick until the early 1990s (Friel, 2009). Coaches soon saw the benefit of training with heart rate monitors and started to utilise them within professional athlete training regimes. Their presence soon became a non-negotiable training aid (Friel, 2009). The heart rate monitor altered the socio-technical practices of professional cyclists and their coaches. Professional cycling teams began to incorporate these devices into their team’s training regimes as a tool to measure the intensity of training sessions and competitive racing (Lucía *et al.,* 1999). The incorporation of heart rate monitors into the training practices of elite cyclists allowed coaches to quantify the demands being put onto the cardiovascular systems of cyclists and help to understand the physiological stresses placed upon the riders (Lupton, 2017).

With heart rate monitors and cadence sensors, cycling became quantifiable to cyclists; rather than riding to ‘feel’, cyclists could train with real-time physiological data (Friel, 2009; Lupton, 2014b). In professional contexts, these technological developments have led to a training framework structured around heart rate zones. Heart rate zones were calculated as a percentage of either a maximum heart rate (the maximum heart rate achieved during a specific exercise that requires exceptionally high levels of exertion) or lactate threshold (produced either during a race or solo time trial effort). Due to heart rate monitors becoming integral to the practices of professional cyclists, there have been many developments in the technology. This has resulted in such technologies becoming available to cyclists of all abilities. Friel (2009) outlines the benefits of incorporating heart rate monitors into training regimes. Specific heart rate training alters cyclists’ practices due to the real-time data (Lupton, 2014b; 2016a) available for the effort they exert, which informs their physical outputs.

As heart rate monitors have become more widely available, they have become embedded in cyclists' practices. Javaloyes *et al.* (2019) studied the effectiveness of training with heart rate monitors among amateur road cyclists. Their study found that by training with heart rate monitors and following specific training plans of moderate and high intensities, cyclists trained more effectively. The incorporation of heart rate monitors into training habits is beneficial to cyclists at all levels, as well as coaches, as they provide “important information that allows you to make decisions as a workout progresses” (Friel, 2009: 46). As Friel (2009) states the information provided gives users real-time insight into their performances that can affect the outcomes of their training. Despite the benefits of training with heart rate monitors, there are also several caveats: diet, stress, sleep, and heat are all external factors that can affect a person’s heart rate. These external effects can result in athletes struggling to reach or stay within their desired training zones (Friel, 2009).

3.3.5 The revolution of power

In 1986, a patent was filed for a crank-based power meter, which was awarded in 1987. Ulrich Schoberer, founder of Schoberer Rad Messtechnik (SRM), developed the first means of measuring an athlete's power output on the bike during real-world rides (SRM, N.D.a). In 1988, the company released its first SRM training system (Figure 3.7). The system consisted of a power meter and a training computer with the ability to record and retain data for later analysis, both of which were the first of their kind. Up until this point, there had been no adequate means for cyclists to measure their performance on the bike; instead, they had to use specialist ergometers in labs. While the use of ergometers could track improvements throughout the duration of their training, there were no real means of quantifying a cyclist's performance throughout the duration of a specific ride, race, or workout (Passfield *et al.,* 2017; SRM, N.D.)

Figure 3.7 SRM Powercontrol Training System (SRM, N.D.b).

Power is a measure of work compared to time; in terms of cycling, this is the size of the gear (work) compared to the cadence of the cyclist (time), so if the size of the gear is increased and the cadence stays the same, the power increases (Freil, 2009). Since their conception, power meters have quickly become one of the main ways cyclists monitor and evaluate their training and race performances (Passfield *et al.,* 2017). Power meters address the shortcomings of other training metrics, such as heart rate. As mentioned in the previous section, training to heart rate has its limitations, such as "delayed response to the stimuli, and difficulties for the precise assessment of intermittent efforts" (Sitko *et al.*, 2020: 1; Friel, 2009). Friel (2009: 51) states that "heart rate monitors are even more beneficial than they were before, now that there are power meters." As a result, power meters are considered to be the most reliable measure of performance and training outside of laboratory testing (Sitko *et al.*, 2020). Klika *et al.* (2007) subjected 56 participants to an eight-week training class twice a week lasting for one hour utilising power meters. Power output ranges were calculated before the training program, and subsequent training sessions were based on those values. At the end of the training period, Klika *et al.* (2007) found that participants' fitness had significantly increased along with their maximal power output.

The SRM power meter system was widely adopted by professional cycling teams for training and racing (Passfield *et al.,* 2017; SRM, N.D.). The SRM crank-based power meter has found itself as the "standard against which all others are compared" (Passfield *et al.,* 2017: 1426). However, in the last 40 years, there have been a multitude of developments in power-measuring technology. While the method of measuring power by strain gauges that measure the torque produced, the approaches to measuring power output vary. There are crank-based power meters (SRM and Stages), Pedal-based (Garmin and Favero), and Hub-based (Cyclops Powertap), to name a few. While the list is not exhaustive, there are new companies bringing out more affordable and innovative ways of measuring power output. The widespread use of power meters within the professional peloton has helped to drive the manufacturing of power meters into the amateur consumer markets.

Training with power meters has evidently been around for many years within the professional peloton; however, the use of such technology was not readily available for the consumer market until 2005. However, the professional peloton had been training with power in varying forms since its inception. Early adopters such as Greg LeMond started to use power meters early on to much success, claiming that "it was a major transformation" (Bailey, 2015). Many professional cyclists made their own training plans or had input from team coaches prior to the use of power meters. However, their training plans similarly remained focused on covering big mileage and racing (Sidwells, 2019). For Hunter Allen, an American cycling coach, the invention of the power meter removed the guesswork from training. This allowed coaches to accurately quantify the training their athletes were doing and allowed them to plan, through specific training regimes, when an athlete would reach their peak fitness (Sidwells, 2019).

The use of power meters had reshaped the practices of cyclists in such ways that it had begun to affect the ways athletes actually raced (Shove, Pantzar, and Walker, 2012). When asked about racing with power meters, Alberto Contador (Professional cyclist for Tinkoff at the time) stated, “Power meters do take some excitement out of races […] they make everything more controlled” (Reyes, 2016: n.p). Contador was referring to racing against Chris Froome of Team Sky. Team Sky notably used power meters to train and race with, causing much contention over recent years amongst fans and some professional riders. Team Sky’s use of power meters was so successful that there were calls for them to be banned from racing (Hood, 2018). Professional riders like Nairo Quintana stated that they “take away a lot of the spectacle and make you race more cautiously”, and Alejandro Valverde claimed, “they take out a lot of drama from the sport” and that “in competition, you should be racing on feelings” (Reyes, 2016: n.p).

While there were calls for power meters to be banned from racing during Team Sky’s dominance within World Tour Races between 2012 and 2018, power meters have remained a staple part of professional training and racing (Hood, 2018; Reyes, 2016). Due to the great success and strategies of using power meters, particularly for Team Sky in the Tour de France, power meters were receiving more coverage during professional races, news, and social media outlets. Along with the coverage, adverts for consumer power meters were shown during televised races. The power meter had begun to solidify itself as an exceptionally useful tool for cyclists and coaches (Friel, 2009; Hood, 2018; Passfield *et al.,* 2017; Reyes, 2016).

3.3.6 The emergence of socio-technical cycling assemblages

GPS had been available to the United States of America's military since the early 1970s and was eventually made publicly available in 1983. The public release of GPS was to ensure the safety of air travel in the wake of Korean Flight 007 being shot down by Soviet Aircraft after straying into restricted airspace (Britannica, 2021; McDuffie, 2017). Despite being made public, the GPS was scrambled, providing the public with approximately a 100-metre radius of accuracy (McDuffie, 2017). With this availability, new forms of navigation technology were developed incorporating the use of GPS. Gary Burrell and Min H. Kao founded Pronav (later renamed Garmin) in 1989 and released the GPS 100 for use in marine and aviation navigation (Garmin, N.Da). By the late 1990s, there had been a number of developments within the field of portable technologies, particularly GPS-enabled mobile phones (such as Garmin and Benefon) and even a GPS-enabled watch (Byford, 2015; Garmin, N.D.a; Ravikumar, 2020). However, many of these innovative designs were constrained due to the limitations imposed on public GPS.

President Bill Clinton signed a bill in 2000 stating that the end of these limitations would allow greater GPS accuracy to be available to the public (McDuffie, 2017). This created technological advancements in turn-by-turn navigation, with companies like Garmin developing the StreetPilot, which provided motorists with audible navigation instructions (Garmin, N.D.a). In 2003, Garmin released their first sports-focused GPS device – the Garmin Forerunner 101, followed by the 201 later the same year (Garmin N.D.d). The Forerunner built on existing technologies to quantify their activities by providing users with a digital map created from the GPS data recorded during the activity (Garmin, N.D.d; Gerwick, 2005). Along with this, the device also provided users with real-time data such as speed, pace, and distance. However, these initial devices suffered from GPS reliability issues in built-up and heavily wooded areas (Gerwick, 2005). These new devices were soon recruited into the practices of athletes; although designed for running, cyclists were finding ways to mount them to their bikes. Forum posts provided would-be users with novel ways of mounting them to their bikes using items like "pipe insulation” (jch2112, 2004: n.p). Garmin soon developed handlebar mounting kits for their GPS devices.

The Forerunner 101 could store approximately two years’ worth of activities; however, the device could not upload them to a computer. This was rectified with the Forerunner 201 (Figure 3.8), which was accompanied by computer software. The introduction of computer software enabled users to download their rides and provided them with a new means of self-surveillance, the monitoring of personal activities through the use of technology, and self-quantification (Lupton, 2017). The use of the technology and software soon (co)evolved as users started to develop ways to overlay their GPS data on satellite images of the Earth (Wants2rideFast, 2005). By 2006, Garmin released the Edge series of GPS devices that were designed specifically for bikes. These GPS-enabled bike computers would allow cyclists to “take your ride to the next level” (Garmin, N.D.c). The release of the Garmin Edge 305 (Figure 3.9) brought with it the ability to connect heart rate monitors and cadence sensors. Cyclists were now able to quantify their rides in more detail than ever before. Garmin’s training centre computer software also allowed users to map routes, elevations, and training rides. The development of this software was the beginning of cyclists’ spatial interactions, which became (co)produced with their technology (Shove, Pantzar, and Watson, 2012).

Figure 3.8 Forerunner 201 (Garmin, N.D.d).

Figure 3.9 Edge 305 (Garmin, N.D.c).

Early iterations of these GPS-enabled devices facilitated users to track their activities; however, with the release of the Garmin Edge 305 and its incorporation of bodily sensors, this transitioned once again to directing the ride. These cycling assemblages were able to record and analyse their cycle rides in more detail than ever before. The use of software allowed users to plot routes and relive their past activities (Barratt, 2017). In recent years, numerous developments in GPS technologies (the inclusion of multiple satellite systems such as the Russian GLONASS and European GALILEO systems) have revolutionised the use of bicycle computers. Modern-day devices can detect incidents and subsequently notify the user's next of kin with their location. Furthermore, these devices enable users to be directed by attached sensors that provide real-time data on their bodily exertion. This is further influenced by the ability to download detailed training plans that instruct cyclists on how to ride through detailed workouts designed around their power outputs and/or heart rate zones. As GPS technologies have become embedded into the practices of cyclists, a suite of applications have developed that further allow for detailed analysis of the data captured by these devices. They also provided integrations that can influence cyclists' motivations through scripts that augment their experiences during their rides. These applications will be explored in section 3.3.7 below.

3.3.7 Smartphones and applications

The smartphone era has begun. Smartphones and the applications that they hold endlessly intersect with everyday practices both passively and actively recording, reminding, tracking, monitoring, and communicating. People engage with their smartphones to differing extents, but a paradigm shift in what it means to be a human in the 21st century has occurred – with smartphones, people are all, to a greater or lesser extent, digitally connected beings. Early iterations of GPS cycle computers like the Garmin Edge 305 had associated computer software that was used for the analysis of ride data. However, web-based applications have since taken their place. These applications have proliferated within the sports and fitness tracking world due to the pervasiveness of smartphones, which have become integrated into people's everyday practices (Allaby and Shannon, 2020). Apple released its first smartphone in 2007, and one year later, in 2008, it introduced the App Store (Apple, 2018). The App Store launched with 500 applications and now boasts over two million (Apple, 2018; Ceci, 2022a), with 80,000 associated with the health and fitness category (Ceci, 2022b). Androids Google Play store also has an equivalent number within their application store (Ceci, 2022a; 2022b).

The release of Apple's iPhone in 2007 transformed the mobile phone market, marking a shift from a device that primarily receives phone calls and sends text messages to a portable computer "with mobile phone functions" (BinDhim and Trevena, 2015: 2). The development of these devices has led to mobile phone functionality becoming secondary to other features these devices offer. Software applications have thrived with the ease with which they can be developed and distributed on these platforms (Mckinnon and Fitzpatrick, 2013). Smartphones have allowed their users to navigate in new cities with the ability to view comprehensive mapping on their devices, look up timetables for public transport, as well as organise their lives across a multitude of different applications (BinDhim and Trevena, 2015). The smartphone (re)shaped the way in which space and place is navigated, with much of people's daily lives being mediated through various applications thanks to the ease of access and distribution of online app stores (Lorinc, 2010; Mckinnon and Fitzpatrick, 2013; Verhoeff, 2012).

Just as people's daily lives were becoming increasingly mediated through applications and technology, so too were their leisure and fitness (Lorinc, 2010; Millington, 2018). Applications like Map My Ride were released onto the App Store in 2008 (App Store Apps, N.D.) and brought self-surveillance and self-quantification to a mass audience. Map My Ride allowed users to use the built-in GPS functionality of their smartphones to record their rides and produce digital artefacts (Figure 3.10 shows a digital artefact produced in Strava). These digital artefacts allowed users to relive and review their rides once the ride had finished (Barratt, 2017). Just like the devices above, Map My Ride provided users with detailed information about their performance through graphs and maps overlaid with metrics like average speed, elevation, distance, and duration. Applications and devices like those outlined above were the starting point for self-quantification that provides users with in-depth self-knowledge through incorporated sensors and self-surveillance (Lupton, 2014a; 2016b; 2017).

Meanwhile, in 2009, a new application was developed, and interest started to increase. Strava was launched, and while initially it was a quiet competitor to Map My Ride, it eventually became one of the most popular cycling applications available (BikeRadar, 2022; Cyclist, 2022; Friend, 2020). In a 2011 VeloNews article, Strava was heralded as the “Technical Innovation of the Year” The article states that digital companies have made it when its name is used as a verb. Its success is marked by the feature set that Strava offers to its user base. Up until 2020, Strava allowed users free access to a plethora of data, allowing users to compare their times on digital segments and compete against other users up hills for places on online leaderboards (Lindsey, 2020). As the proliferation of online social media shaped how people interact online, Strava cemented its place in the athletic community as a space for “Social Fitness” (Lindsey, 2019: n.p). This led to early debates around Strava’s influence upon the practices of cyclists. Dansie (2013) reported that Strava’s influence has changed the social aspect of group rides into formalised online competition. Rather than the sprint for the village sign amongst a cycling club or group of friends, Strava transforms the rides into tangible digital artefacts with online leaderboards that change the practices of those engaged (Dansie, 2013).

While applications like Map My Ride and Strava allow users to experience GPS tracking for their activities, there have been issues with their use. In particular, users have experienced high battery drain on smartphones, particularly while viewing live data during the ride (Rosie, 2021). There are many forum posts of users asking if there are ways to restart rides after the phone battery has gone flat or seeking advice on how to maximise the length of the battery during rides. In addition to the battery drain, the data provided was limited to speed, distance, time, and elevation. To access information such as heart rate, cadence, and power, separate dedicated devices were needed to connect such sensors. While there are now options for Bluetooth-enabled sensors, this was not initially the case (Harris-Fry, 2022). Applications like Strava and Map My Ride exist, with many users making use of the basic features; however, both offer free and paid versions of their applications. The paid experiences of both apps offer users access to unique features and greater insight into the data generated during their activities.

Users are able to upload activities from dedicated GPS devices to services like Strava. Through the app and online website, Strava offers users analysis tools to provide insights into their rides. At its most basic, Strava allows users to visualise information like speed over their ride or in relation to elevation; if users have connected sensors, they can access some more in-depth features, of which even more insight can be gained through a paid subscription (Sawh, 2021a). Strava offers a paid subscription service, most recently known as Strava Premium, referring to paid members as Subscribers (Lindsey, 2020). Subscribers can gain access to a suite of training statistics that allow users to delve into things like fitness and freshness, which allows users to track their fitness over time, identifying trends and allowing users to plan their training around race schedules (Sawh, 2021a). Premium members can also access online training plans for running and cycling provided by Carmichael Training Systems (CTS).

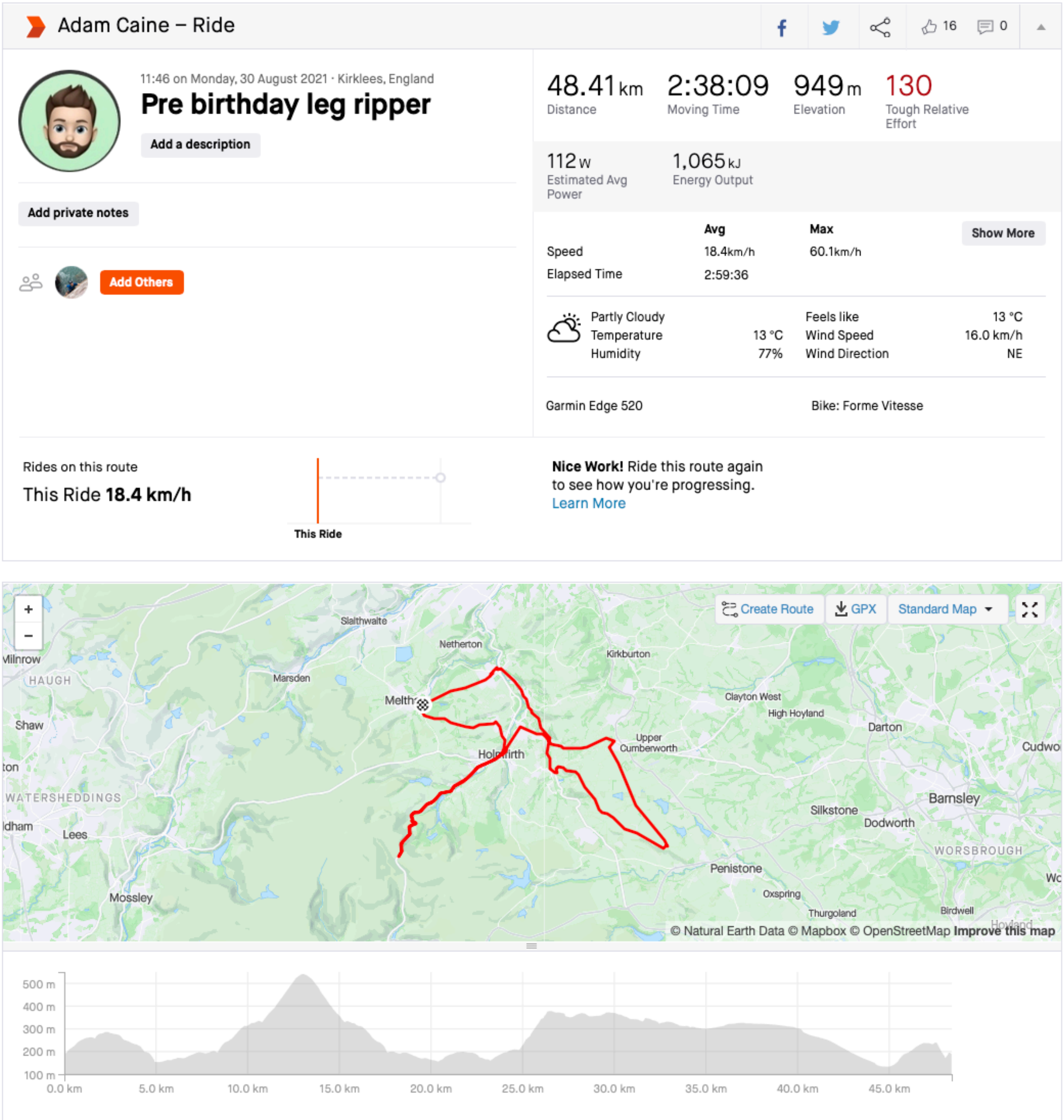


Figure 3.10 Digital artefact - Strava Mapped Ride

While Strava is no longer a unique application (platforms like Garmin Connect and Komoot also provide analysis tools for cyclists), it has retained its popularity amongst cyclists. Strava has become subsumed into the practices of cyclists, and as Barratt (2017) found, its inherent scripts produce cyclists with digital imperatives that compulsively record and monitor their data. Recent developments have seen the integration of Strava segments onto GPS devices that direct users to the start of a segment, counting them down and instructing them to 'go' once they reach the start. Dedicated GPS devices and applications like Strava have facilitated a shift in cycling culture. As Barratt

(2017) found, a key aspect of Strava was the transformation of the bike ride into a digital artefact that existed outside of the confines of the ride itself. These incorporated technologies can inform rides by planning routes according to weather conditions and through digital imperatives to encourage cyclists to ride more (Barratt, 2017).

3.3.8 Future socio-technical developments in Cycling

The previous sections have outlined the socio-technical developments in cycling through the various iterations of bicycles to developments in technology that have facilitated users to quantify their bodies (Lupton, 2014b). Cyclists and technology have been in a constant state of flux. As technology develops, their practices shift to incorporate it into the training regimes. Heart rate monitors showed a notable shift in the (co)evolution of cyclists' practices. As Friel (2009) noted, the importance that training with heart rate monitors had on the ability for professional cyclists to train more effectively resulted in the technology becoming widely adopted within cycling. This wide adoption of technology and increased presence amongst elite cyclists eventually resulted in the technology becoming more available for amateur cyclists. However, the inconsistency of heart rate monitors identified a means for a new training metric that was not influenced by external factors. This led to the development of the power meter, which further (re)shaped the practices of cyclists (Shove, Pantzar, and Watson, 2012).

Moreover, dedicated GPS devices have replaced the past cyclometers that counted down miles from rivets mounted to the bike. Cyclists have become socio-technical assemblages whose practices are informed through a network of bodily sensors that provide real-time information that influences and augments their rides (Barratt, 2017; Shove Pantzar and Watson, 2012). Smartphone applications have capitalised on the embedded practices of self-quantification (Lupton, 2016b; Pantzar and Ruckenstein, 2015) and provide cyclists with a suite of scripts that increase their motivations. These digital augmentations and interactions transform their rides into tangible records that display information about their rides, enter them into digital leaderboards, and can be shared with friends and strangers alike through specialised online social media platforms like Strava (Barratt, 2017).

Cycle training has become further digitally mediated through the use of virtual applications like Zwift. Zwift is an online virtual platform that sees cyclists presented as digital avatars in a virtual world. Reed *et al.* (2022) reported on Zwift's rapid growth within the virtual leisure industry. Zwift provides cyclists a platform to train and ride their bikes indoors, away from the physical spaces normally associated with cycling (Reed *et al.,* 2022; Robertshaw, 2022). Much like dedicated GPS devices bring together the biological sensors that mediate the practice of cycling, Zwift integrates these sensors and provides users with motivational training plans and gamified scripts like those associated with Strava (Robertshaw, 2022). Platforms like Zwift enable users to compete and exercise with peers and strangers online (Westmattelmann *et al.,* 2021). Applications like Zwift are redefining the indoor training market that incentivises and motivates its users through novel digitalisation (Reed *et al.,* 2022; Westmattelmann *et al.,* 2021).

Technology and applications are constantly (co)evolving with the practices of cyclists. Recent developments have seen the introduction of E-bikes (electronic bikes) that have mechanical assistance provided by an onboard battery. These bikes have become particularly popular among commuter cyclists, especially in the Netherlands and Germany (de Haas *et al.,* 2022). E-bikes provide riders with mechanical assistance in addition to their pedalling. Sundfør, Fyhri, and Bjørnarå (2020) found that e-bikes can improve public health, particularly among those with low levels of physical activity, enabling more access to cycling as both a leisure and transport pursuit. The mechanical assistance e-bikes can provide their users allows them to overcome barriers to participation, such as distance, elevation, and physical exertion (Fyhri and Fearnley, 2015; Melia and Bartle, 2021). Technology and applications have also (co)evolved with the production of e-bikes, where users can now log e-bike and e-mountain bike rides. Contemporary research suggests e-bikes can help to overcome barriers to active transport (Melia and Bartle, 2021; Sundfør, Fyhri, and Bjørnarå, 2020); however, more research is needed to understand how these new e-bikes affect cycling as a leisure pursuit.

3.4 Summary

Bicycles and bicycling technology have been in a state of constant (re)invention throughout time. Many of these developments have been borne out of the practices that developed as a result of the technologies adoption. Modern bikes bear a similar resemblance to the Rover of the 1880s, but the technology used to manufacture bike frames, gears, shapes, and aerodynamics vastly differ from those used over 100 years ago. Technology that has become embedded within the self-surveillance and self-quantification practices of cyclists has also developed with its widespread adoption amongst professional and amateur cyclists. These technologies provide users with in-depth information that informs their 'on the bike' decisions based on the real-time data they provide.

> "Expect other technological advances in training. Someday we may opt to have a small biometrics chip implanted that monitors heart rate, reports lactate levels and helps us regulate body glucose. Our friends and spouses may be able to track the progress of our daily rides or races from our homes and cars via Global Positioning Systems." (Friel, 2009: 295).

The above quote from Joel Friel highlights how, as a coach, he foresaw that technology is consistently developing due to the ever-changing practices of cyclists. Cyclists and coaches will find new and innovative ways to track and quantify their progress and abilities in the pursuit of maximising their athletic performances. 13 years since the publication of Friel's *The Cyclists Training Bible* have seen some of these predictions come true. Both Strava and Garmin GPS devices allow users to provide real-time location updates to family or friends. This can be used to ensure their safety or facilitate friends in joining them on their activity (Garmin, N.D.e; Strava, 2021). The Libre 2 sensor was developed to inform diabetic patients about their blood sugar levels and has been repurposed and marketed to cyclists to track their blood glucose levels during their activities. Supersapiens (2022: n.p) states with these sensors, it’s “like having a molecular lab on your arm”. They claim that the incorporation of this technology allows cyclists to train harder for longer, optimise their recovery, and analyse their performance afterwards (Supersapiens, 2022).

The practices of cyclists are in a state of flux with technology. Their practices (co)evolve with and (re)shape the technology as it becomes embedded within their socio-technical assemblages. Health and fitness devices, applications, and integrations are a continually growing market (Millington, 2018). As Barratt (2017) writes, these developing technologies are shaping the engagements both on and off the bike. While this chapter does not provide an exhaustive list of all the technology available to cyclists, it provides an insight into how both the technology and the practices of cyclists are (co)produced through each enactment (Shove, Pantzar, and Watson, 2012). Self-surveillance and self-quantification have become embedded within the practices of cyclists through the proliferation of devices that enable self-monitoring to take place (Pantzer and Ruckenstein, 2015; Lupton, 2016b; 2017; Shove, Pantzar, and Watson, 2012). The later empirical chapters will build upon the socio-technical developments explored within this chapter.

The next chapter explores the theoretical frameworks that inform the research. Practice theory will be explored and then applied later in the thesis during the empirical and discussion chapters. Along with practice theory, the chapter examines the growing body of research into the blurring of digital and physical spaces through digital geography concepts such as code/space. Finally, Chapter 4 summarises the contemporary themes of cycling within academic research.

Chapter 4: Digital geographies: theoretical understandings of practice and socio-technical interactions

> "Software is thus actively shaping sociospatial organisation, processes, and economies, along with discursive and material cultures and individuals' construction of identities and personal meanings." (Kitchin and Dodge, 2011: xi).

4.1 Introduction

This literature review provides an overview of the academic and theoretical background that has been applied to the case study of cycling. It reviews the current academic research on cycling and other cognate disciplines, as well as exploring relevant literature relating to digital geographies, particularly surrounding how physical and digital spaces are experienced. This research aims to investigate the complexities of the socio-technical assemblages of cyclists and their pursuit of cycling. Cycling is a pursuit that has become increasingly mediated through dedicated GPS devices, associated applications, and performance-tracking technologies. The effects technology has had on the practices of cyclists before, during, and after the enactment of cycling has been a central theme to the study. Examining cycling in this way will help to explain the links that are formed and shaped through the practices of cyclists and understand how their experiences become contingent upon their socio-technical assemblages.

The theoretical framework that underpins this study is practice theory. Practice theory builds upon the work of Actor Network Theory (ANT) and Science and Technology Studies (STS). Like ANT and STS, practice theory understands that things and objects can and do affect the habits, routines, and practices of their human counterparts (Latour, 2000). However, practice theory moves away from the ANT approach and examines the assemblages of elements that make up a practice which endures through the links made between each constituent element (Reckwitz, 2002; Shove, Pantzar, and Watson, 2012). This study will draw upon practice theory to understand how the digital (re)shapes, (re)configures, and mediates the production of space and the effects it has on human interactions and experiences (Ash, Kitchin, and Leszczynski, 2019). As a result, this chapter will focus on how practices come into existence, how they endure over time, how they eventually die, and how they become embodied by their carriers (Amin and Thrift, 2007; Eden, 2016; Reckwitz, 2002; Shove *et al.,* 2007; Shove and Pantzar, 2005; Shove, Pantzar, and Watson, 2012). It will also examine the current literature embracing the digitally mediated interactions surrounding spatiality (Graham and Zook, 2013; Kitchin and Dodge, 2011; Leszczynski, 2019; Thrift and French, 2002), mobilities (Cresswell, 2010; Jestico, Nelson, and Winters, 2016; Schwanen, 2019), and digital health (Chen, Zdorova, and Nathan-Roberts, 2017; Dobbins and Rawassizadeh, 2015; Millington, 2018) with an emphasis on how these mediated interactions sustain digital practices. This chapter informs the research and highlights gaps within the current discourse that this research aims to populate.

4.2 Structure of the chapter

This chapter begins by outlining practice theory and how it is helpful when theorising how humans, objects, and space transect each other through numerous different links that become embodied within their practices. This leads to a discussion of practice theory, the central theoretical underpinning of the research, and the development of its key concepts through examining the work of its key contributors. This section will also outline how practice theory has previously been used to understand how practices emerge, endure, and die. This is an area that is helping to explain and understand how human practices are changed and affected by technologies and associated applications. It also has key implications within human geography to help understand how spatial interactions are (co)produced and (co)evolve over time.

Digital geographies are explored next. Digital geographies explore how spatialities and everyday life are becoming increasingly mediated by technology and applications (Thrift and French, 2002; Ash, Kitchin, and Leszczynski, 2019). This section explores how the pervasiveness of technology affects the way that space, mobility, and health are increasingly influenced and conceptualised through technology. First, this section explores the conceptual frameworks developed to understand the effects of the digital on the experiences of space, starting with *Hybrid Spaces,* moving to *Digital Shadows and Augmented Realities,* and finishing with *Code/Space.* Once the key theories of each framework have been explored, the section moves on to how the digital mediates mobility by exploring how the digital has become entwined with the key tenets of mobility: movement, representation, and practice (Cresswell, 2010). Lastly, it explores the implications that self-surveillance, self-quantification, and mobile health have on the concept of the self and identity and how such practices emerge within fitness, technology, and society (Lupton, 2014; Millington, 2018).

Finally, the chapter outlines the contemporary themes of cycling within academia. This section highlights the wider academic debates in cycling through the corporeal experiences of cyclists and what this means when participating in the practice of cycling. This literature, drawn together, illustrates how a lack of cycling infrastructure results in cycling for utility, in the British context, feeling inaccessible and dangerous (Aldred, 2012; Aldred, 2016; Aldred and Crossweller, 2015). It also examines the propensity to cycle tool (Lovelace *et al.,* 2017; Poole *et al.,* 2011) before considering how cycle commuting has beneficial impacts on health funding (Burgess, 2013) and culminates with Jones' (2014) account of the emotionless maps generated by GPS-recorded cycling activities.

4.3 Practice theory

Practice theory underpins much of this study and has been a useful conceptual tool for thinking through the increasingly digital practices of cyclists. Later empirical discussion will rely on practice theory due to its flexible and robust analytical approach that will help elucidate the nuanced and contradicting narratives of cyclists' socio-technical developments. Such a theoretical understanding of practices and what they entail will enable the research to break down cyclists' practices into their constituent parts and understand the roles they play within their experiences. It will also show how cyclists' technologically mediated practices become routinised and how technology (re)shapes and (re)configures their experiences that, result in digitally augmented spatial interactions. The following section of this literature review outlines how practice theory enables understanding of cyclists' socio-technical assemblages in the following ways: the constituent elements that practices are made of, how practices emerge, endure, and die, how people (practitioners) are recruited into practices, and finally, how practice theory relates to the socio-technical experiences of cyclists, their motivations, meanings, and competences within the subsequent empirical and discussion chapters later in the thesis.

Practice theory emerged from academic contributions in the 1970s and early 1980s with the work of Bourdieu (1977), Giddens (1984), and late Foucault (Schneck, 1987). Bourdieu's work was centred on the concept of *habitus*: the understanding of embodied practices as the collective consciousness, norms, and conduct of social groups. These practices are created not as a result of structures of free will but as a result of the interconnectedness of previous events and structures (Bourdieu, 1990; Shove, Pantzar, and Watson, 2012). Giddens (1984) developed his theory of practices through a framework of structuration, "that is, activities are shaped and enabled by structures of rules and meanings, and these structures are, at the same time, reproduced in the flow of human action" (Shove, Pantzar, and Watson, 2012: 3). For Foucault, however, his theories attempted to understand and analyse the relationships between the body, agency, knowledge, and understanding (Reckwitz, 2002). These early moves towards a theory of practice resonated with scholars like Schatzki (1996, 2002) who marked a change toward a more "diffuse movement" in social practices (Shove, Pantzar, and Watson, 2012: 6). Reckwitz (2002) provided a more cogent understanding of practice theory with his paper *Toward a Theory of Social Practices,* in which he drew together the foundations laid by Bourdieu, Giddens, Foucault and Schatzki. For Reckwitz (2002: 15), "social theories are vocabularies necessarily underdetermined by empirical 'facts'. As vocabularies, they never reach the bedrock of real social world but offer contingent systems of interpretation which enable us to make certain empirical statements”.

Both Schatzki (2002) and Reckwitz (2002) agree that practices are formed by (co)produced assemblages of artefacts, materials, technologies, bodies, and knowledge. This moves away from the ANT approach favoured by scholars like Latour (2000). There are some common themes, however, that traverse both ANT and practice theory, notably, that in other areas of social theory, “things are unfairly accused of being just ‘things’” (Latour, 2000: 11). Both practice theory and ANT understand that things, objects, and materials have their part to play within the development and continuation of practice (Latour, 2000; Reckwitz, 2002; Schatzki, 2002; Shove, Pantzar, and Watson, 2012). Practice theory examines the assemblages of elements that are interlinked to form a practice. Without such links between elements, practices can no longer take place (Shove *et al.,* 2007; Shove, Pantzar, and Watson, 2012). For practices to endure, they rely on the linking of their elements; this requires the links to become entwined and embodied within the practices themselves but also with the practitioners through each subsequent (re)enactment (Shove, Pantzar, and Watson, 2012). The assemblages put forward by Schatzki and Reckwitz are identified as three constituent parts: materials, competencies, and meanings (Shove, Pantzar, and Watson, 2012).

To fully understand how practices develop and become routinised, it is important to understand the constituent elements and the links that they form. For Shove, Pantzar, and Watson (2012), these elements are defined as follows:

- **Materials** encompass the objects, infrastructures, tools, and technologies. These are the tangible entities that mediate interactions with practitioners. In this definition, they are to practice as ‘things’ are to ANT.
- **Competences,** when incorporated into practices, are not themselves physical entities (competencies as physical entities will be discussed

later). When recruited into practice, they form the know-how, cultivated skills, background knowledge, and practical consciousness required to perform or judge the performance of the practice.

- **Meanings** are not the driving force of motivation for practices, but they are the emotions and symbolic significances that are attached to the practices with each performance. It is through subsequent (re)enactments of these practices that meanings are developed and cultivated.

For practices to exist, a link must be formed between these three constituent elements. If links between them break down, the practices are no longer effective and become dormant or, in some cases, die. As a result, for practices to survive, links between the elements require continual renewal, making the links central to the practice itself (Shove *et al.,* 2007; Shove, Pantzar, and Watson, 2012).

Practices emerge with the linking of elements (Latour, 2000; Shove *et al.,* 2007; Shove, Pantzar, and Watson, 2012) that become embodied within the experiences of their practitioners (Amin and Thrift, 2007). The emergence of new practices has been well documented in Shove and Pantzar's (2005: 43) examination of the "invention" and subsequent "reinvention" of Nordic walking. For this new practice to emerge, it required replacing old meanings ascribed to walking with sticks (previously aligned with images of frailty, old age, and disability) with new meanings (images of health, well-being, and fitness). This supports the significance of the role non-human actors play within the lives of the practices and with their practitioners (Latour, 2000), and that producers are not able to freely develop new products, and with them new practices. It is a process of (co)production between producer and consumer. Nordic walking became interlaced with images of public health in Finland, with assistance from the Finnish government (Shove and Pantzar, 2005). Another reason Nordic walking quickly became established was due to the requisite elements already established in other practices: sticks are used within skiing, and a form of early proto-practice (roller skiing) (Shove, Pantzar, and Watson, 2012) used by serious athletes to train for skiing during the off-season (Shove and

Pantzar, 2005). Due to this, the meanings of health, well-being, and fitness were ascribed to the use of sticks in other practices, allowing the linkage of elements to take place (Shove and Pantzar, 2005). As a cognate leisure practice, this study applies the ideas from Nordic walking to cycling, with the added complexities that digital assemblages bring to the practices and further understanding of the effects that digital technologies have on broader leisure pursuits.

Although Nordic walking managed to become a developed practice within Finland and spread through Europe to Austria and Germany, it did not manage to emerge in the United Kingdom as easily. This shows that the emergence of practices may not occur in other cultures or social settings in the same or similar ways (Shove and Pantzar, 2005). This diffusion of practices is not as simple as transporting the requisite elements from one place to another; the relevant skills need to be enabled, competencies and meanings need to be decoded, (re)produced, or even (re)invented (Shove, Pantzar, and Watson, 2012). Material objects travel easily by means of road, sea, and air; however, competencies are required to be decoded by the intended practitioners. Competences are not usually physical entities in this respect, but they can be manifested within instruction manuals and video tutorials or taught by those who already subscribe to the practice (Shove, Pantzar, and Watson, 2012). It is in the decoding of competencies that, when linked together with the relevant materials, practices become (re)invented, (re)imagined, and assigned new meanings associated with social and cultural background knowledge (Shove and Pantzar, 2005; Shove, Pantzar, and Watson, 2012). Practices, then, do not necessarily emerge in new settings just because the requisite elements are present. Potential practitioners are required to make links that (re)create a version of that practice, and through subsequent (re)enactments, these configurations are subject to (co)evolve (Reckwitz, 2002; Shove and Pantzar, 2005; Shove, Pantzar, and Watson, 2012). If the links begin to break down or meanings are no longer significant, practices begin to die (Shove, Pantzar, and Watson, 2012).

As seen by the propagation of Nordic walking, the emergence of new practices is not as simple as exporting the material elements to new and unknown cultures (Shove and Pantzar, 2005). Competences are more reliant on the would-be practitioner's inherent tacit knowledge to decode and decipher them. Meanings develop through moments of (re)enactment, where they can (re)emerge through declassification and reclassification (Reckwitz, 2002; Shove, Pantzar, and Watson, 2012). With these subsequent (re)enactments, meanings and motivations for participation were cultivated within the practice. As each new (re)enactment occurs, the practitioners and practices (co)evolve; this can occur through (re)developing competencies and meanings that have become embodied by the practitioner (Shove and Walker, 2010; Shove and Pantzar, 2016). This embodiment of practices is important to understanding how new personal and social meanings become attached to the practices.

Propagation of practices can seem like chance encounters or unpredictable experiences; however, in some circumstances, practices can overlap with similar practices. In these cases, practices can emerge and recruit new practitioners through social contagion between friends with similar interests (Shove, Pantzar, and Watson, 2012). Practices, then, can be shared through mutual interests and social groups. In this case, practices can occur through associations with similar practices, referred to as '*Bundles'* by Shove, Pantzar, and Watson (2012); they argue that practices can develop from separate practices that can merge and develop into another distinct practice over time. More recently, Barratt (2017) has used practice theory to understand the effects of tools such as gamification on the experiences of cyclists. Gamification uses elements such as leaderboards, progress bars, graphs, and badges (Sailer *et al.,* 2013) as extrinsic motivators to encourage increased engagement. Such practices have developed and taken hold since Strava (a social network for athletes) emerged, where users upload their rides, runs, swims, and many other outdoor, indoor, and virtual athletic endeavours. While it is important to recognise cycling as part of a broader bundle of digital practices, a full examination of this is not within the scope of this thesis. As such, the digital cycling practices will be examined as a distinct and separate practice. To understand the extent of the practices of cyclists, practice theory allows the research to explore the requisite elements inherent to the (re)production of the practice itself. As new recruits participate in these digital cycling practices, they become enmeshed within the wider community of practice. Through each (re)enactment, their experiences, expertise, and identities (co)evolve.

For cyclists, these practices are becoming embedded as social norms through material and social networks; as new cyclists join the sport, so too are they recruited into digital practices. Digital cycling practices did not emerge overnight; as discussed above, they have emerged through the linking of relevant elements, some of which have been transferred from similar digital practices. Dedicated GPS technologies have become more widely available for mass consumption. This has resulted in more cyclists being able to afford the relevant materials to participate in these digitally mediated practices. Similarly, over the last 20 years, online social media platforms have become a more routine part of society, with voluntary sharing on sites like Facebook, Instagram, and Twitter paving the way for specialised applications like Strava to provide an online space for athletes (Ash, Kitchin, and Leszczynski, 2019). Further to this, practices endure when practitioners experience internal or external satisfaction. Sharing their rides online via Strava allows practitioners to see quantifiable self-improvements over time and experience external satisfaction through social interactions, such as kudos and comments from online friends and followers (Shove, Pantzar, and Watson, 2012).

For Schatzki (2002), Reckwitz (2002), and Shove, Pantzar, and Watson (2012), practices are enabled by their constituent elements. Later empirical discussion will rely on this basis when examining cyclists' socio-technical assemblages. However, the research will also explore how cyclists embody these practices and how this influences their interactions with physical environments. The empirical discussions will expand beyond materials, competencies, and meanings to consider the subjective experiences of the practitioners and how they become embedded within the practitioner's emotional experiences. Therefore, this research will approach digital cycling practices by examining cyclists' narratives and exploring how their socio-technical assemblages (co)evolve through each performance (Hand, Shove, and Southerton, 2007). Furthermore, it will deepen understanding of the internal motivations and meanings that practitioners ascribe to their practices based on their emotional and embodied experiences. Examining practices in this way will provide greater insight into how the performance of and engagement with digital cycling practices encompasses more than just competencies. They involve a diverse network of experiences, emotions, and senses that have become integral to the practice, and as such, it will help to identify why Strava has successfully become entrenched within many cyclists' practices and what the implications of this might be for future policy objectives around health and sustainability (Eden, 2016).

4.4 Socio-technical practices and digital geographies

This section investigates the blurring lines between digital and physical spaces. Firstly, this section explores how spatiality is (re)produced through the digital by exploring conceptual frameworks such as: *Hybrid Spaces, Digital Shadows and Augmented Realities,* and *Code/Space*. Next, digital mediations of mobility are explored, followed by the implications of self-surveillance and self-quantification (Lupton, 2016b; 2017). Thrift and French (2002) theorised about the changing spaces of everyday life and the ever-increasing incorporation of technology into practices and experiences. More recently, it has become evident that everyday practices are interlaced with technological and digital counterparts. Social, economic, and cultural practices are mediated through digital systems, from personal computers to data centres to smartphones and applications (Ash, Kitchin, and Leszczynski, 2019).

For geography, the digital, sometimes referred to as virtual geographies (Kinsley, 2014) or internet geographies (Graham, 2014), has led scholarly research to consider the digital as both object and subject within the research. This focus allows researchers to examine how the digital (re)shapes, (re)configures and mediates the production of knowledge and its influence on practices and human experiences (Ash, Kitchin, and Leszczynski, 2019). For Thrift and French (2002), the production of space is now an inherently digital phenomenon whereby digital technology (re)shapes interactions with and perceptions of space. The pervasiveness of digital technology "signals a fundamental reorganisation of the environment as the digital transects every aspect of everyday life"; it is "a part of the extended organism of a new form of humanity" (Thrift and French, 2002: 329). The digital is no longer an *'actor'* as Latour (2000) theorised, but it has become subsumed into the very practices that make up modern life (Ash, Kitchin, and Leszczynski, 2019; Shove, Pantzar, and Watson, 2012). As a result, digital geographies are complex and dynamic (Zook *et al.,* 2004), made up of no single entity, they encompass a variety of subjects and objects, and specialities and effects from varied digital practices (Ash, Kitchin, and Leszczynski, 2016). Daily life is punctuated by the ever-increasing importance of social media platforms. As Ash, Kitchin, and Leszczynski (2019: 1) state:

> "Many aspects of cultural life, including how we identify and socialise with others, express ourselves, and consume popular content and entertainment are now highly mediated through social media platforms such as Facebook, Twitter, and Instagram."

Individuals who would once have journaled or sealed to memory their everyday lives now share their experiences through digital platforms such as Facebook, Twitter, and Instagram (Humphreys, 2018). This transformation of social interaction and recording of daily life and its various practices has become ubiquitous and has led to the existence of specific practice-based platforms like Strava, Garmin Connect, and Komoot that allow sporting communities to socialise online, turning practices into tangible digital artefacts (Ash, Kitchin, and Leszczynski, 2019; Barratt, 2017).

"Digital individuals" is a term used by Curry (1997: 695) to describe the increasing amount of data created and time spent connected to everyday technologies. As 'digital individuals' enmeshed within digital practices, technology enables "individuals more freedom and control of the process of constructing new (and often highly personal) geographies of how and where they create and consume information" (Zook *et al.,* 2004: 168). The impact of digital technology has become of increasing interest, particularly in terms of mobility. For Verhoeff (2012: 145), mobile telecommunication devices encourage new navigational practices “through the embodied motion of the navigator” as they move through space. GPS-enabled devices not only enable a new way of negotiating physical spaces but are also an increasingly essential part of leisure and sport. These digital devices come in a variety of forms and with accompanying sensors and applications that mesh together, enabling users to engage in self-surveillance and self-quantification of their sporting and fitness activities (Sanders, 2017). Millington (2018) notes the fitness market is booming, especially in relation to smartphone fitness applications and wearable technologies like Garmin and Fitbit. Undoubtedly, health, leisure, and fitness have been subsumed into the “age of the app” (Lorinc, 2010). This has seen a rise in fitness and health tracking mediated by technology and applications that not only track exercise, sport, and leisure but are designed to track users day and night, providing metrics such as resting heart rate, heart rate variability, and sleep tracking through their associated applications, resulting in the boundary of the self and the quantified self becoming blurred. Millington (2018) refers to this as Fitness 2.0. Yet digital transitions at play within everyday practices have not been explored by scholarly research, something this research seeks to address.

Wearable technologies and their associated applications of Millington’s (2018) Fitness 2.0 encourage their users to track their daily practices at all times. Practices such as tracking everyday life through wearable technologies, sensors, and other forms of self-surveillance are commonly referred to as the quantified self (Chen, Zdorova, and Nathan-Roberts, 2017; Lupton, 2016b; Pantzar and Ruckenstein, 2015). For Lupton (2016b: 3), the quantified self “refers to using numbers as a means of monitoring and measuring elements of everyday life and embodiment”. For users who fall into the quantified self movement, the technology exists as a means to “incite behavioural change” (Dobbins and Rawassizdeh, 2015: 1423). According to Chen, Zdorova, and Nathan-Roberts (2017), the uptake of wearable fitness devices and associated applications has been high but has also suffered from high levels of abandonment. They found that a key component to encouraging new and existing users to continue their use of such devices was through gamification

(Chen, Zdorova, and Nathan-Roberts, 2017). Barratt (2017: 330) found that fitness-tracking apps such as Strava had a “persuasive influence” on cyclists. This has been achieved through inherent scripts within Strava that present data in gamified ways. As mentioned previously, Strava displays data to its users through digital leaderboards, achievements, progress bars, and other key performance indicators indicative of gamification (Sailer et al., 2013), which will be discussed later in this chapter.

For sports such as cycling, there has been notable popularity within the community for the use of dedicated GPS devices to record and track individuals’ rides. Devices range in their levels of sophistication from smartphone applications to dedicated cycling computers and wearables such as sports watches. Strava has become one of the most popular activity logging and sharing applications, with around one million new athletes (Strava’s term for their users regardless of experience) joining each month and boasts 19 million activities uploaded to the website every week (Strava, 2020a). Cycling and the effects that ride logging applications have on cyclists have largely been unresearched, with the exception of Barratt (2017), Boss *et al.* (2018), Broach, Dill, and Gliebe (2012), Jestico, Nelson, and Winters (2016). Applications like Strava provide users with a means of self-surveillance and self-quantification of their activities; however, despite not advertising itself as a gamified website, its inherent scripts and mechanisms draw strong parallels with those of gamification (Barratt, 2017; Millington, 2018).

The use of digital technologies in self-surveillance and self-tracking practices enable new ways of understanding how users relate to their urban physical environments (Merchant, 2016). These devices can alter perceptions of space by viewing their environments through a “quantitative lens” (Esmonde, 2019: 6). Cycling and running are two leisure activities where associated digital technologies and applications are of note. Cyclists, in particular, have been found to have increased motivations due to their use of digital technologies (Barratt, 2017); however, more work needs to be done to understand the emotional and physiological experiences technology can have on individuals (Merchant, 2016). Further to Barratt (2017), Couture (2020) found that applications like Strava can encourage users to participate in technologically mediated self-surveillance practices that foster increased motivations. The use of technology during activities not only leads to increased motivation but can also have implications on how cyclists interact with their physical environments and can enhance their enjoyment and performance through real-time feedback (Esmonde, 2019).

Experiences of increased motivation were coupled with the sense of community and sociability that associated applications such as Strava provide to their users (Barratt, 2017; Couture, 2020). Without the sociability, sustained changes did not occur. Kerner and Goodyear (2017) found that adolescents using FitBit experienced initial increases in their motivation, but due to a lack of wider health education, predetermined health goals, and the inability to set personalised goals, motivations waned after four weeks. However, by increasing users' motivation, sports and leisure activities can also become contingent on the use of digital technologies (Couture, 2020). This can have negative implications on users' self-perception, as Fletcher (2023) found the use of an Apple Watch led to increased scrutiny enabled by the self-surveillance functionality of the device. The heightened self-surveillance coupled with social surveillance can also lead users to experience performative stress when data does not represent their expectations (Esmonde, 2019). Increased personal scrutiny can also reinforce simple health narratives of being either ‘fit’ or ‘fat’ (Goodyear, Kerner, and Quennerstedt, 2017). These fat-shaming narratives were also experienced by Fletcher (2023: 482), who felt their own “negative body size perceptions intensified through smartwatch self-tracking”. Despite this, the world of self-tracking devices and digital technologies are growing, and more work needs to be done to thoroughly understand the implications that these devices can have and how they are continually (co)evolving with their users and (re)shaping their leisure practices (Esmonde, 2019). This research intends to further develop a contemporary understanding of digital technologies that enable self and social surveillance, particularly focusing upon the complexities that associated applications such as Strava that further intersect motivations, community (Barratt 2017), self and social surveillance, and privacy concerns

(Couture, 2020), as well as increasing gendered narratives of sporting masculinity (Wellard, 2006; Barrie, Waitt, and Brennan-Horley, 2019)

Stragier, Evens, and Merchant (2015) conducted an initial study into the motivations of athletes uploading their activities to social media networks. The results of their study found that intrinsic motivations of self-surveillance and self-quantification were the driving factors. However, they also concluded that these results may have occurred due to the research design (Stragier, Evens, and Merchant, 2015). As a result, more work needs to be done to further understand the motivations behind the online sharing of leisure activities. Further to this, Silk *et al.* (2016) stated that current research in the form of digital leisure practices is not keeping pace with the consumers and producers. Not only is research not apace, but it also needs to account for the contradictions, complexities, and nuances within the narratives of digital technology users (Silk *et al.,* 2016; Stragier, Evens, and Merchant, 2015). How these digital integrations shape and alter the socio-technical relationship needs further research. Barratt (2017) has highlighted the importance of further research into the contemporary practices of cyclists can further debates in active transport, leisure, mobility, and gender disparities within sport. This section introduces the digital and explores how it transects every aspect of daily life. Moreover, it moves to highlight how the digital is important not only for shaping practices but as a key interest to the geographies of spatiality and mobility and the role it plays in understanding the leisure practices of cyclists (Ash, Kitchin, and Leszczynski, 2019; Barratt, 2017).

Geographers are becoming interested in the digital and its impact on the geographies of everyday life (Duggan, 2017). Recent scholarly work in geography has focused on the impacts digital technology has had on networked and location-based interaction as both subject and object (Ash, Kitchin, and Leszczynski, 2016; 2019). Though recent work within geographic and social science debates have focused on socio-technical developments, as Redhead (2016: 13) notes, “urgent questions on digitisation remain unanswered”, especially regarding the influence of technology on embodied spatial interactions - something that this research intends to answer. As Thrift and French (2002) stated, everyday practices are increasingly mediated through technology, and as a result, the digital has become increasingly enmeshed with the analogue. The result of this meshing together of digital and analogue means daily practices are increasingly comprised of networked socio-technical interactions that are “impossible to tell where one begins and the other ends” (Elwell, 2014: 235). As everyday life is increasingly augmented and mediated through technological interactions such as smartphones, applications, and social media platforms, it is important that these socio-technical interactions are considered within the “key aspects of geography, space, place, and mobility” (Duggan, 2017: 14) and in particular the “ways in which the digital has pervasively inflected geographic thought, scholarship, and practices” (Ash, Kitchin, and Leszczynski, 2016: 1) as both subject and object.

Just as digital geographies are key in understanding socio-technical interactions, they also play an important role in understanding how socio-spatial (spatiality) relations are mediated through technology. The diverse array of location-based devices and applications have transformed the production of space from purely cartographic endeavours orchestrated by states, governments, and organisations to a socially mediated practice of connected individuals (Leszczynski, 2019; Millington, 2018). With a shift in the production of maps the process needs to be reconsidered, where the production of maps and spatiality is an important aspect of digital geographies (Wilson, 2019). Duggan (2017) writes that space is a key aspect of technology studying spatiality, and the influence the digital has on technology, social, and spatial relations is key in understanding how space is produced. As previously stated, observing the digital as both the subject and object of the research is important to identify the different relationships between space produced through technology (Ash, Kitchin, and Leszczynski, 2019; Leszczynski, 2019). Considering engagements with non-human technologies and their (co)production and (re)configuring of space, there are several frameworks that explore how the relations of digital technologies and space are linked: *Hybrid Spaces, Digital Shadows and Augmented Realities,* and *Code/Space.* Each framework provides key theories on the role the digital plays in spatiality and socio-technical relations that will become clear in the following paragraphs.

Hybrid spaces have been an initial approach when considering technology in the production of space and spatiality. This initial approach to the relationship between technology and space worked on the basis of two distinct domains becoming entwined (Leszczynski, 2019). It was once theorised that as technology became more pervasive, the lives of individuals would become more online with a reduced importance of mobility. However, as Frith (2012: 131) notes, “the digital information of the internet has begun to merge with physical space”. Although these spaces were once distinct, they have been brought together through mediated interactions of mobile technologies (de Souza e Silva, 2006). This conception of hybridity works on the notion that digital and physical spaces are physically distinct (Leszczynski, 2019). However, modern location-aware smartphones have led to the two domains no longer being ontologically distinct. The proliferation of smartphones “allow users to be constantly connected to the internet” (de Souza e Silva, 2006: 261) while interacting within physical spaces. Live tracking and biosensors used in conjunction with fitness applications problematise this conception of hybridity further with place, body, and technology implicitly linked.

Just as technology has become embedded within the practices of everyday life, it has also become the interface through which connected individuals access hybrid spaces (Leszczynski, 2019). The smartphone has enabled individuals to remain connected, which, according to Wilson (2014), has enabled new types of interactions that have led to theories of hybridity. These new types of interactions through location-based applications and services can influence interactions within space through such hybrid assemblages (Zook and Graham, 2007). Zook and Graham (2007: 480) explored how the algorithms of Google Maps transform it from more than just a map; it is an “interactive space that influences how people interact with their local environment”. However, as Leszczynski (2019) writes, when theorising spatiality, hybrid spaces rely on digital and physical spaces being distinct and only recently becoming hybridised. This notion fails to acknowledge that digital spaces are, in fact, comprised of physical entities like data centres, internet exchanges, and deep-sea fibre optic cables.

Hybrid spaces examine how the digital and physical worlds have become entwined, but for Graham (2013: 117), places are “no longer just confined to their material presences: they have become digital and digitised”. By focusing predominantly on urban cityscapes due to their increased user presence, Graham (2013) examines the digital shadow cast upon cities. These digital shadows are created by the ubiquitous use of social media, sensor networks, and the Internet of Things (everyday objects with embedded sensors that enable them to send and receive data), transforming cities beyond just bricks and mortar. As more information is created and added to the layers, cities and spaces are increasingly experienced through their digital shadows (Leszczynski, 2019). This can occur when geocoded content is tailored to the user through complex algorithms. Graham and Zook (2013) found that searches conducted in different languages at the same location returned vastly different results that can, in some instances, further entrench linguistic segregation. The result of cities being “increasingly translated into data” means that it also shapes the way in which space is experienced both socially and culturally (Leszczynski, 2019: 17). Further to digital shadows, Graham, Zook, and Boulton (2013) look at the augmentations and how such generated digital information influences the everyday lived experiences of places designated as augmented realities. These augmented realities are a “material/virtual nexus mediated through technology” (Graham, Zook, and Boulton, 2013: 465).

Augmented realities move away from distinct separations of the digital and physical, arguing that such domains “have always been inextricably linked” (Graham, Zook, and Boulton, 2013: 465). Augmentation has the ability to not only influence how space is experienced but also offer new ways of interacting with the space (Graham, Zook, and Boulton, 2013). However, more recently, the ability for users to augment reality by means of smartphone applications has allowed users to further mix physical and digital environments (Liao and Humphreys, 2014). This new level of augmented reality is allowing users to change the “augmented representation of places” (Liao and Humphreys, 2014: 1433). As Leszczynski, (2019: 17) writes:

> “Space is always in the process of becoming, and this becoming is performative by virtue of being highly subjective and contingent on the technologies present and available to differently embodied subjects.”

Consequently, as more content is generated and as technologies evolve, the production of space is subject to change with the interpretations of individuals who are exerting virtual power to reconstruct how spaces are experienced (Leszczynski, 2019; Liao and Humphreys, 2014).

The construct of augmented realities builds directly on the work of Kitchin and Dodge’s (2011) theory of code/space. This theory works on the (co)production of space through pervasive software that has become intimately entrenched in everyday life. In code/space, everyday life is increasingly mediated by code and software such as utilities (power, water, gas), banking, government records, and even household appliances (Kitchin and Dodge, 2011; Zook and Graham, 2018). Code/space occurs through the mutual constitution of software and space, resulting in the (co)production of space through one another (Kitchin and Dodge, 2011; Gieseking, 2017). The effects of code/space can be defined in areas where spatiality is the outcome of code; as a result, code and spatiality exist in a dyadic relationship. Kitchin and Dodge (2011) use the example of an airport check-in area, where the process of checking in is reliant on the software to be able to check-in passengers; the failure of such software renders the space defunct due to manual check-in procedures being phased out on security concerns. Therefore, “the production of space is dependent on code” (Kitchin and Dodge, 2011: 17).

However, the production of space is not reliant on code in all instances. In places where software enhances or augments the space (like that of Graham, 2013), the space is termed a coded space. In this instance, software enhances the space, but the relationship between code and space is not dependent. An example of coded space is during a presentation whereby a PowerPoint influences the presentation of the speaker and transforms the spatiality of the lecture theatre, but where its failure does not cause the presentation to cease (Kitchin and Dodge, 2011). In this regard, while the lecture is not contingent on the software, it does enhance the experience and effectiveness of the talk for both the presenter and the audience (Kitchin and Dodge, 2011; Leszczynski, 2019). Spatiality is affected by the prevalence of code within the area and how it is utilised (Dodge, 2017; Leszczynski, 2019). As Dodge and Kitchin (2005: 178) write, “Code/space is a form of transduced space wherein the production of space is wholly dependent on code”. Such a dyadic relationship can also recast previously non-coded spaces as code/space (Leszczynski, 2019). The resultant spatiality is changed through code/space. Such changes centralise code and software as an integral part of the production of spatiality: “software quite literally conditions” the existence of space (Thrift and French, 2002: 312; Kitchin and Dodge, 2011; Leszczynski, 2019).

Just as software and technology have become an integral part of the production of space, mobilities have also become increasingly mediated through technology. A clear example of this is the effect of code/space on the aviation and shipping industries. The example given above regarding the aviation industry shows how it can no longer operate or function as required with a failure of code/space (Kitchin and Dodge, 2011); the same can occur with respect to the shipping industry (Schwanen, 2019). Failures of such code/space can have detrimental impacts on the transportation of goods and services on a global scale (Schwanen, 2019). However, it is not only the mobility of freight that is affected through the use of technology. The proliferation of smartphones in recent years has created an environment where people are always connected and has transformed the speed at which information can be shared and accessed (Millington, 2018; Schwanen, 2019). Technology has begun to mediate forms of human transportation from cars that are controlled by software to “targeted smartphone apps” (Schwanen, 2019: 60) that accompany runners and cyclists participating in Millington’s (2018) Fitness 2.0 (Barratt, 2017; Verhoeff, 2012).

For Cresswell (2010), mobility is constituted of movement, representation, and practice. Movement is the process of getting from one place to another; representation is the meaning derived from the process of movement; and practice is the experience and embodiment of movement (Cresswell, 2010). Research in digital geography seeks to understand how technology has become entwined within these tenets of mobility. The results of such research have begun to shed light on how embedded technologies have started to reconfigure the everyday practices of physical movement (Schwanen, 2019). Practices are increasingly mediated through wearable technologies made by Garmin and Fitbit that track users' activities and are then logged, shared, and quantified through online applications such as Strava and Garmin Connect (Millington, 2018). The proliferation of smartphones and wearable technologies for exercise and leisure falls into Wilson's (2014) notion of continuous connectivity. This enables users through location-based services to quantify their activities through a plethora of self-surveillance sensors and applications (Lupton, 2016a; Wilson, 2014).

Self-surveillance in the form of fitness tracking applications has become a popular pastime amongst cyclists, runners, and other athletes. Applications such as Strava have become a popular platform for users to upload their activities and track their performance over time (Barratt, 2017). These applications have become popular in terms of mobility due to their use of gamification, and in some cases, have been found to increase the level of motivation among their users (Barratt, 2017; Chen, Zdorova, and Nathan-Roberts, 2017; Schwanen, 2019). As Schwanen (2019: 61) writes:

> "The incorporation of the digital has not eviscerated the importance of space and place to the constitution of mobility systems, practices, and experiences and it has probably increased rather than reduced socio-spatial inequalities of mobility."

This can be seen in the way gamification has been used within schemes to encourage active transport (see Coombes and Jones, 2016; Yen, Mulley, and Burke, 2019). However, within such trials, there has been a lack of long-term change in practice. The lack of success is, in part, due to a lack of social integration within the designs and implementations of such schemes (Thiel, 2016). The mediation of mobility through technology has (re)shaped and (re)configured the ways in which individuals conduct their exercise. However, the increased use of technology and the (co)production of space by code and software have led to some inequalities in access to mobility infrastructures (Kitchin and Dodge, 2011; Schwanen, 2019).

Further research towards self-surveillance and self-quantification has occurred in the field of mobile health (sometimes referred to as mHealth). Bodily functions become “digitised” and “quantifiable” (Lupton, 2014a: 615). This mirrors the experiences of those taking part in Millington’s (2018) Fitness 2.0, whereby personal ideas regarding health and fitness are addressed by the technology and their data is neatly displayed in the accompanying applications (Lupton, 2014a). Mobile health applications and technologies have provided users with biological feedback that is present both during and outside of activities. Activity trackers provide users with feedback about sleep, stress, daily steps, and resting heart rates, while during exercise, they can be linked with further devices such as power meters and continuous blood glucose monitors that provide even more insight into their own performances in order to enable users to achieve their health goals (Lupton, 2014a; Alger, 2021). The use of technology and applications to track health and fitness allows the users to feel empowered and “extends the temporal nature of health surveillance” (Lupton, 2012: 234; Sharon, 2017). In this respect, self-surveillance is already normalised through native health applications found embedded in smartphones. Native refers to the health applications that are preinstalled onto devices and track daily movements such as steps, and distances walked, at times “without our knowledge”, as Millington (2018: vi) found. Tracking activity through native health applications found on both Apple and Android smartphones means that when users move to social platforms like Strava, comparing and quantifying their data (against themselves) has already become normalised, and applications like Strava further normalise comparative practices by allowing users to compare against their peers (Sharon, 2017). Wearable technologies are a growing field with technology companies finding new and inventive ways to analyse and influence wearers' practices. The effects of these wearable technologies are ever-evolving as the practices and spatial interactions of cyclists adapt to the ever-growing field of self-surveillance and quantification (Schüll, 2016).

Self-surveillance and self-quantification are playing an ever-important role within the pursuit of cycling. As Barratt (2017) highlighted, digital applications are increasingly mediating the practices of cyclists, but more research is needed to understand the changes that occur in practices through their use. Contemporary debates focus upon the health benefits of cycling (Section 4.5 below). However, policy initiatives currently fail to achieve long-term changes to routines and habits. Through the following research, cyclists' use of applications will be explored to understand the impact that engaging with applications like Strava can have on policy interventions for health and well-being (Barratt, 2017). As Millington (2018) and Lupton (2017) note, self-surveillance and self-quantification increase the intrinsic motivations within those actively engaged. Moreover, research into the digitally mediated practices of cyclists can also inform wider debates on mobilities (see Cook, 2021). As Cook and Larsen (2022: 8) write, "further investigation by geographers and their analyses of how bodies, experiences, places and movement are mediated by such technologies" is needed.

4.5 Short synthesis on academic approaches to cycling

> "Cycling is probably the most sustainable urban transport mode, feasible not only for short trips but also for medium-distance trips too long to cover by walking." (Pucher and Buehler, 2017: 1)

This section seeks to explore some of the more contemporary themes of cycling research, particularly how such themes fit into the affective intensities embodied within the practices of cycling. There has been substantial research around cycling, with particular attention to cycling's potential as a sustainable, environmentally friendly, and healthy form of transportation, as the quote above suggests. A number of initiatives, such as the Mini-Holland Programme in London (Department for Transport, 2020), have also attempted to transform cityscapes into more friendly spaces to encourage more journeys to be undertaken by bicycle. The majority of these initiatives seek to improve either facilities for cycling or current perceptions towards cycling. The following paragraphs explore the various approaches research has made in exploring cycling while identifying the lack of discourse on the use of digital technology within cycling.

In recent years, there has been a steady increase in the number of people who participate in cycling (Department for Transport, 2021; 2022). However, little research has been conducted in understanding how their cycling is influenced within the places they cycle. It is important for such research to take place to understand how these contemporary themes are embodied by both leisure and commuter cyclists. Phil Jones's (2005; 2012; 2014) and Justin Spinney's (2005) autoethnographic accounts of cycling reveal the corporeal effects leisure and commuter cycling have. This research directly responds to Dunlap *et al.* (2021: 2), which calls for an understanding of cyclists' "lived experiences through the emotional and affectual engagement with the very processes that not only functionally move them through the […] landscape, but that speak to their expressions of identity and purpose".

Jones (2012) and Dunlap *et al.* (2021) use Pile's (2010) theory of affect to help explore the everyday life of cycling. For Jones (2012: 645), this was used as a way to understand his own commuter cycling and "theorising the intertwining of body and words as a set of intensities, both positive and negative". Affect can be used to understand how individuals have different capacities that can prevent them from taking part in situations that fall outside their capacity for sensory stimulation (Pile, 2010). Jones (2012) applies these affective intensities to transport, stating that in the UK, motorised transport, particularly cars, are more incorrigible due to their reduced affective intensity. The reduction of intense sensory stimulations is encouraged by the current state of the economy, whereby consumers are encouraged to seek safety, particularly through means of transport. Cycling, particularly as transport, is an intense form of affective experience and is at a juxtaposition with the current sense-scape for consumers (Jones, 2012). This research aims to understand the motivations of cyclists and whether applications like Strava transform such intense forms of affect into more palatable experiences.

The economic favouring of cars as a safe form of transport has led to the development of cities focused largely on the movement of motorised vehicles with a distinct lack of investment in alternative forms of transport (Dunlap *et al.,* 2021), the only exception to this being pedestrianised shopping zones in city centres. This has led to a large number of UK cities being surrounded by major roads (Aldred, 2012). The development of car-centric cities within the UK has resulted in cycling having to fit in within the confines of current infrastructure. This is a direct result of cycling being excluded from transport policy until the 1990s, when its environmental and health benefits were first acknowledged (Cahill, 2010; Goldbluff and Aldred, 2012). This exclusion from transport policy and lack of cycling infrastructure has led to the UK being what Jones (2012: 646) refers to as a “bicycle unfriendly country” and that cycling “can be physically challenging and, at times, actively dangerous”.

While the potentially dangerous experiences of commuting by bike in Birmingham were enjoyed by Jones (2005), his reflective account is not representative of the experiences of all commuter cyclists. Many are frequently reminded of the inherent risks of cycling with the frequency of near-miss incidents they experience (Aldred, 2012; Aldred, 2016; Aldred and Crossweller, 2015). The dangers that are faced by activities as ‘mundane’ (Michael, 2000) as commuter cycling produce intense sense-scapes that can trigger adrenaline rushes that are enjoyed by some but deemed illicit and undesirable by others (Jones, 2005; 2012). For many, these intense affects are a barrier to cycling, especially commuting at peak times on already busy roads. Statistically, cyclists have a higher risk of death or serious injury per mile than those travelling by motorised vehicles (Aldred and Crossweller, 2015; De Hartog *et al.,* 2010). Statistics like this help feed subconscious ideas that cycling is dangerous and has undesirable levels of “sensory stimulation” (Jones, 2012: 646), whereas other forms of transportation do not.

Much of the contemporary literature focuses on the improvement of cycling infrastructure (Aldred, 2012; Koglin and Rye, 2014; Sanders, 2015) and increasing cycling as a form of active transport (Aldred, Croft, and Goodman, 2019; Latham and Wood, 2015, Lovelace *et al.,* 2017). The improvement of infrastructure and initiatives like the London Mini-Hollands programme are effective in "increasing active travel and improving perceptions" (Aldred, Croft, and Goodman, 2019: 12). Other initiatives like the propensity to cycle tool have been developed to identify areas where there is potential to increase the uptake of cycling (Lovelace *et al.,* 2017). The tool was developed to locate areas of cities where there was likely uptake of cycling for transport and to help local governments implement cycling infrastructure to facilitate cycling instead of car journeys (Lovelace *et al.,* 2017; Pooley *et al.,* 2011). Infrastructure for cycling has been largely an afterthought within UK transport planning and has resulted in cycle lanes that are either considered too narrow or are ignored altogether by motorists (Pooley *et al.,* 2013). However, it is also worth noting that "not everyone is willing to travel at speed balancing on a thin metal frame while tonnes of automobile thunder past often within touching distance" (Jones, 2012; 649). Although building infrastructure helps to reduce the perceived dangers of cycling, it is still, especially in cities, a hostile experience. As a result, it is not sufficient to just simply build infrastructure (Tortosa *et al.,* 2021; Hong, McArthur, and Livingston, 2020). Cycling needs to be understood from the inside and "the lived phenomena that constitute the affectual and embodied engagement of biking" (Dunlap *et al.,* 2021: 9).

In addition to improving infrastructure, cycling has also become a topic of debate in environmental and health research. Various studies have shown that cycling is a recreational activity that improves health (Kaczynski & Henderson, 2007), and by cycling to work, a person's risk of mortality is reduced by 40 per cent (Hendriksen *et al.,* 2010). More specifically, the benefits of regular physical activity reduce the risk of obesity, diabetes, and heart disease (O'Hern and Oxley, 2015). This has further been supported by reported reductions in costs for healthcare that occur when investment in cycling infrastructure is made (Burgess, 2013). However, tensions arise between a policy that encourages sustainable transport, like cycling and the undesirable affective intensities that are associated with it in countries like the UK (Jones, 2012). Even though cycling is a sustainable mode of transport, Behrendt (2019) found that discussions regarding sustainable transport often centre around the use of smart autonomous vehicles. This focus on smart mobility seems to have developed with the increasing presence of smart cities. The result of this is that the discourse on sustainable transport has been usurped by the promise of electric vehicles and smart mobility (Behrendt, 2019).

Despite an increasing call for the development of cycling infrastructure (Aldred, 2012; Koglin and Rye, 2014; Sanders, 2015) and for people to take part in active transport (Aldred *et al.,* 2019; Latham and Wood, 2015; Lovelace *et al.,* 2017), there are many people who lack the relevant experience to undertake such journeys (Jones, 2012). The pursuit of cycling, for transport or leisure, is an act, a performance that requires participants to absorb and react to an array of complex practices dependant on the places in which they are cycling, whether that is through the rhythms of conquering Mount Ventoux (Spinney, 2005) or the forever evolving understanding of commuting through the city of Birmingham (Jones, 2005; 2012; 2014). Cycling is an embodied act of reimagining and reinventing the spaces in which it takes place. When Jones (2005: 822) talks about his experiences of commuting through Birmingham and feeling like an “unruly cyclist”, he unashamedly admits to breaking the rules of the road in order to ensure his own safety.

In contrast to much of Jones’s accounts (2005; 2012), Davidson (2021: 12) argues that much of the discourse surrounding the improvement of cycling infrastructure and the development of greener and safer streets focuses predominantly on “white, masculine, able-bodied, middle-class” men and that as a result, other demographics are inadvertently labelled as “undesirable”. Much of what Davidson writes focuses on how current discourse fails to account for the unequal experiences of large swathes of the population. This can also be seen in the London Mini-Holland programme, where Kingston-upon-Thames, Enfield, and Waltham Forest all have large populations of White British/Irish residents (Department for Transport, 2020). Davidson (2021) directly questions research on mobilities like cycling and highlights the inherent discriminatory nature of much of the policy. This approach builds further on research that examines the gendered nature of cycling (Aldred, 2013; Aldred and Jungnickel, 2014; Pooley *et al.,* 2011; Goldbluff and Aldred, 2012), taking it one step further and highlighting how improvements for one sector of society directly and negatively impact and force other demographics to experience poorer qualities of life (Davidson, 2021).

While much of the research engages cycling within contexts of mobility and transport planning, it is important to understand cycling as a sport and leisure pursuit. Barratt (2017) identified how digital technologies, particularly applications like Strava, are (re)shaping cycling practices that encourage cyclists to engage more intensely and frequently with the pursuit. This integration of digital technology has not only happened with cycling but also with other sports, such as running and mountain biking. Cook and Larsen (2022) explored the effect of digital technologies on everyday running practices and the importance they play in tracking activities and fostering new ways to maintain social bonds through sporting social networks. The evolution of cycling as a leisure practice, particularly through the lens of practice theory and digital gamification, underscores the (co)evolution of practices where physical and digital worlds merge to create enriched experiences (Barratt, 2017; Shove, Pantzer, and Watson, 2012). More work is needed to understand the implications technology has on cycling as both a sport and leisure practice.

Despite much contemporary research focusing on the pursuit of road cycling, it is also important to consider the effects technology is having on sub-disciplines within cycling. While road cycling and mountain biking take place in very different spatial environments, they share common themes such as thrill-seeking and challenges inherent in navigating diverse environments (Cherrington, 2022; Jones, 2005;2012; Spinney, 2005). This research intends to build on the work of Barratt (2017) and create a more nuanced understanding of the developing digital practices within cycling. The research intends to use cycling as a case study to understand the wider implications technology can have on the experiences of those who participate in all forms of active leisure.

4.6 Summary

While much of the research on cycling focuses on safety and infrastructure development, more research needs to be done on the use of GPS devices amongst cyclists. With the exception of Barratt (2017), little is known about the spatial effects digital technologies have on the experiences of cyclists. The most prevalently used case for these devices is to record the cyclists' movements through space. This technology is a useful aid in understanding where cyclists ride; however, on its own, it can be 'unremarkable' (Jones, 2014). In this respect, Jones reflects on the use of GPS data to create art while riding through the city. While the GPS device performed as expected, it lacked the emotions and corporeal experiences that he felt while enacting the performance (2014). To better understand the practices of commuter and leisure cyclists, such data needs to be considered with the effects on their experiences. Both Jones (2005; 2012; 2014) and Spinney (2005) note that the performances of cycling (re)imagine and (re)embody space and place with each subsequent enactment. While their accounts of cycling are inherently different, one borne out of a commute to work and the other out of the experience of cycling up a French Alp, both accounts' experiences show that the experience of cycling is more than just the movement of a body through space. It imbues the rider with feelings (re)defined with each stroke of the pedal and, more recently, each data point recorded via GPS devices, transforming their movements through space (Jones, 2005; 2014; Spinney, 2005). This study intends to build upon research surrounding active transport and leisure practices of cyclists, using cycling as a case study and examining the narratives of cyclists to directly understand their "experiences through the emotional and affectual engagement" as they move through space, place, and time (Dunlap *et al.,* 2021: 2).

To conclude the literature review, it would seem that many aspects of daily life are mediated through digital technology interactions. Experiences of place and space are fundamentally produced through digital interactions (Thrift and French, 2002). This early identification from Thrift and French (2002) of the blurring lines between digital and physical spaces has since become a burgeoning area of research in digital geographies. The development of theoretical frameworks such as code/space proposed by Kitchin and Dodge (2011) forms the building blocks of much of the contemporary research in this area. While much of life is mediated through technology, such as banking, governmental records, and home appliances, so too are everyday experiences. Social media has become a prolific part of producing everyday spatial experiences, with users sharing their everyday engagements through online platforms, something that once may have been an intangible experience is recorded and produced as an artefact that can be shared and relived a myriad of times online (Ash, Kitchin, and Leszczynski, 2019; Barratt, 2017). Experiences that previously would have been confined to memories or private journals are shared online for all to see and experience as software and technology permeate all aspects of life (Humphreys, 2018; Kitchin and Dodge, 2011).

The development of social media networks has facilitated a boom in the fitness industry, particularly in the prevalence of wearable technologies and GPS-enabled recording devices. Deemed Fitness 2.0 by Millington (2018) encompasses the boom in performance-based training metrics that have become enabled with the development and widespread usage of associated applications such as Strava. Self-quantification has become a big factor amongst cyclists and other athletes, and applications such as Strava have become staple platforms for users to upload their rides and feed into their continually connected lives (Barratt, 2017; Lupton, 2016b; Wilson, 2014). Current research has shown that technology (re)configured how users exercise, but more research is needed to understand how it influences and changes their practices as they are (re)shaped and (re)configured with each subsequent performance (Kitchin and Dodge, 2011; Schwanen, 2019; Shove, Pantzar, and Watson, 2012).

This review of current academic literature has focused predominantly on how technology has become interwoven with every facet of daily life. It highlights the building blocks of digital geographies through code/space (Kitchin and Dodge, 2011), Digital Shadows and Augmented Realities (Graham, 2013), and Hybrid Spaces (Leszczynski, 2019) and how they develop and inform current understandings of how place and space are experienced through a world increasingly mediated by technology. Moving on from this understanding, Millington’s (2018) Fitness 2.0 boom builds the foundation of this research identifying the increasing demand of athletes utilising technology in ways to quantify their exercise habits and making use of wearable activity trackers. This research intends to develop and build on current understandings of how this technology is utilised by cyclists. Underpinned by practice theory, this understanding will be discussed in later empirical chapters to ascertain how exactly technology is encouraging their practices to change and how they interact with the physical spaces as they perform increasingly digital enactments of cycling.

The following chapter details the methodological approach used to elicit detailed narratives from engaged cyclists. These methods will provide the empirical information required to answer the research questions by drawing upon the theoretical frameworks outlined in this chapter.

Chapter 5: Methodology: sampling cyclists and their technological assemblages

5.1 Introduction

This chapter provides details of the methodology and sampling strategy employed during this research project. It also considers and acknowledges the positionality of the author at the time of the research. The theoretical approach of the research called for detailed narratives from respondents to elicit a deep understanding of their technologised practices in response to the research questions. The main methodological approach was to use semi-structured interviews. This method allowed the research to be flexible and responsive to the information divulged by respondents (Bryman, 2008; Longhurst, 2010). A topic guide was constructed and piloted on a sample of ten interviewees. Following this, the topic guide was revised for the remaining 28 interviews. The revision of the topic guide allowed for the interviews to explore and elicit more detailed narratives from the respondents. Each interview was transcribed, analysed, and used to develop any emerging areas or narratives that could be further probed to again elicit deeper insights from future interviews.

The methodology was designed to be flexible and adaptable as the research developed. Semi-structured interviews allowed the research to elicit detailed personal accounts from the sample of cyclists (Longhurst, 2010). Interviewing participants in this way allowed the research to take a conversational approach while remaining “self-conscious, orderly, and partially structured” (Longhurst, 2010: 103). The process of interviewing continued until data saturation occurred (Bryman and Burgess, 2002; Bryman, 2008). The chapter begins by discussing and exploring the author's position within the research and how, as an experienced cyclist, it was beneficial to the study. The chapter then outlines the methods employed throughout the research process before discussing the application of inductive analysis to the qualitative transcripts. Inductive analysis was used in conjunction with NVivo computer software to code each transcript in turn.

5.2 Positionality: a first-hand account of experiences

I begin this section by examining my personal values and experiences that influence my position as a matter of being open and acknowledging what I bring to the research process (England, 1994). This account delineates my position in relation to the research subject and its participants (Qin, 2016). As such, I aim to think reflexively about how my own experiences and positionality could affect others but also how participants of the research could influence me (Robertson, 2002). It was, therefore, vital to understanding my positionality before, during, and after the research. The opportunities that have been afforded to me are essential to the research, particularly to cycling, a pursuit that can be considered expensive and middle class (Awasthi, 2021) as well as a gendered (ONS, 2019; Barrie, Waitt, and Brennan- Horley, 2019).

At the start of the research, I was a 26-year-old white, able-bodied, heterosexual male cyclist from a middle-class background. I am, therefore, familiar with the various contexts of cycling within the UK and the cultural norms of cyclists in the UK. Therefore, I can be considered part of the cycling group, an insider, particularly amongst my white male respondents. However, while I identify with many of the cyclists I interviewed, my experiences and identity as a heterosexual, middle-class, white male can be viewed as different towards some of my respondents. This was particularly evident within the interviews of some of my female respondents who had first-hand experiences of discrimination and vulnerability. It is, therefore, important to highlight my own privileges within cycling to situate the lens through which this research is conducted.

I have been lucky enough to experience many of the various disciplines within the pursuit of cycling; for several years, as a teenager, I participated in BMX cycling. After a brief gap, I returned to cycling through my proximity to Cannock Chase and its cultivated mountain biking trails network. My enjoyment of cycling as a recreational leisure pursuit was furthered when a family friend offered me the use of a road bike. With this opportunity, I began to explore the roads of South Staffordshire in the pursuit of steep hills to cycle up and long winding descents to ride down. My enjoyment of road cycling led to purchasing my own road bike. Since then, I have been a member of various cycling clubs and participated in many organised events. While living in South Staffordshire and as a member of Stafford Road Club and Run and Ride Cycling Club allowed my cycling to progress further; I learned much about the sport from other club members. Before embarking on this research, cycling was my predominant form of exercise, leisure, and, for a short time, commuting.

Personal technological developments occurred during my time as a cyclist. While initially exploring the local trails on my mountain bike was recorded with a Cateye device (a brand of cycling computer) attached to my handlebars, the development of smartphones ushered in new digital forms of tracking. Map My Ride quickly became a feature I used during my cycling pursuits, though my personal experiences highlighted its limitations. Frustrations I would later find through this research were also shared with other cyclists. As my road cycling progressed, I also began to explore further afield, initially recording as much of the ride as possible with Map My Ride while having written turn-by-turn instructions on a piece of paper taped to my handlebars. The release of Strava came just as my rides were exhausting the abilities of Map My Ride. A result of being recruited into the practice of recording my rides led to a thirst for more data. This resulted in purchasing my first GPS device, a Garmin Edge 800. This came with a cadence sensor and heart rate monitor. My recruitment into technologised cycling had taken place.

Having been a cyclist for some time and being involved within the community, I understood that there are many sub-genres within cycling, and those who take part in cycling aren't so easily grouped, often taking part in multiple disciplines within the pursuit. As such, I understand that the participants may also participate in more than one aspect of cycling and define themselves in a way that best reflects their preferred aspects of the pursuit and perceived abilities. For instance, as a cyclist, I have taken part in mountain biking of various disciplines, road cycling, and cycle commuting, though I would never consider myself a commuter cyclist. I, however, predominantly enjoy exploring quiet country roads in the Derbyshire Dales and nearby Peak District, looking for hills to explore and ride up; I enjoy seeking out as much elevation gain on my rides as I can, and as such consider myself to be an experienced road cyclist. I prefer spending my time cycling on my own or with a small group of friends. I have experienced the local club runs with a bustling peloton, but at this point, it isn't something I readily seek. It is with this knowledge of my corporeal enjoyment of cycling that I readily understand the relationships and enjoyments experienced by each of my participants. Therefore, as I approach the research, I have insight into and understanding of the cycling community.

At the beginning of the research, I was a 26-year-old male who had experienced first-hand the freedom of exploration that is afforded by a bike: the distance covered under one's power, the connection with open spaces, and the ephemeral experiences of cycling up and down the hills of Staffordshire, Derbyshire, and the Peak District. After reading the literature, my understanding of cycling began to change; my understanding of interactions with space experienced while cycling was more than in-the-moment experiences. My concepts of everyday mobility are increasingly permeated by technology, transforming the concomitant ideas of space and experience (Jones, 2005; Spinney, 2006). This developed my academic and personal understanding of the pursuit. Along with the academic research, I began to reacquaint myself with the cycling world. I started reading online cycling magazines and articles, printed magazines, online blogs, and video blogs. Many of these sources reflected on the introspective, meditative aspect of cycling, likening sitting on the saddle, legs rhythmically turning the pedals, hands resting on the handlebars, as a time to relax and reflect (Kreimer, 2013).

While my cycling experiences have been rich and varied, I have also had the privilege of experiencing them without trepidation (Davidson, 2021). I later discovered through my research that many of my female respondents were not afforded the same privilege. This is mirrored in mobilities research (Aldred *et al.,* 2017; Ravensbergen, Buliung, and Laliberté, 2019). When it came to joining cycling clubs, participating in group rides or events, or even embarking on my first road ride, I did so without hesitation, without consulting a map, and without a sense of fear or anxiety. I have previously considered my experiences of cycling alone on busy A roads, narrow country lanes, and everything in between to be the reason for my confidence. When discussing these experiences with my female respondents, I am an outsider; our experiences of cycling are different.

With this understanding of my positionality in the cycling community and place as a researcher, I am afforded the ability to navigate the intricacies of the jargon-filled landscape cyclists operate within. I can effectively communicate with fellow cyclists, discussing and understanding their ephemeral experiences. I have experienced first-hand the development and permeation of cycling technology and applications in my own cycling and witnessed the same among friends. This understanding allows me to reduce the difference between interviewer and interviewee, and as a result, it reduces the mutual power relations otherwise experienced. However, one caveat may arise when interviewing less experienced cyclists, where my position as a researcher and experienced member of the cycling community could exacerbate the power dynamics of the interview. In these such situations it is important for me to acknowledge my position and conduct the interview in a manner which will reduce any possibility of bias from the respondents.

5.3 Sampling Cyclists

Cycling is a gendered sport, particularly within the UK. The demographic make-up for cyclists is made up of 71% male and 29% female, according to the Office for National Statistics National Travel Survey (2019). This demographic is based on what the National Travel Survey classes as ‘Stages’ defined by the UK Government as where the mode of transport changes (Lovelace *et al.,* 2017). The measurement is useful as it allows cycle trips that are part of multimodal journeys to be included. The demographic of cyclists is further broken down into key age groups. 64% of journeys recorded were aged between 21 and 59. Cycling has been a growing sport within the UK, with an increase of 100,000 participants from 2018 to 2019 (Sport England, 2019). Accurately representing the demographic of cyclists was important to the research, and the sample for the research can be seen in Table 5.1. Participants were recruited to represent the gender demographics identified and a stratified sample of ages to represent the wider cycling community. A further breakdown of the participants can be seen in Table 5.2, which shows the gender, age (at the time of participation), preferred cycling discipline, and pseudonym to maintain their anonymity within the research. The research also called for participants to use cycling technology such as applications and dedicated GPS devices, information that is not directly sourced within any of the statistical information available.

	Male	Female	<16	17-20	21-29	30-39	40-49	50-59	60-69	70+
ONS	71%	29%	17%	4%	12%	17%	20%	15%	8%	6%
Sample	68%	32%	0%	3%	23%	20%	20%	23%	8%	0%

Table 5.1 Gender and Age demographic of cyclists in the UK compared to interview sample (ONS, 2019)

Although cycling popularity has increased since the 2012 Olympics and the British Tour de France wins, cycling still remains highly gendered. 71% of cyclists are male and predominantly white middle class (Steinbach *et al.,* 2011; ONS, 2019). This can also be seen when out cycling, at the start line of cycling Sportives, bike parks, and cycling clubs, all of which men make up the majority of cyclists. As part of the research, it is important to reflect the demographic and to make sure that women are represented accurately within the data.

Contemporary research has identified themes within the gendered nature of sport. Research has identified that female cyclists have expressed different cycling needs within cycling such as a preference for segregated cycle lanes (Aldred *et al.*, 2017). This is in part due to women having a lower propensity to risk than men (Byrnes *et al.,* 1999; Charness and Gneezy, 2012). Recently, there has been a growth in research into the gendered nature of gamification utilising themes of sporting masculinity (see Wellard, 2006; Barrie, Waitt, and Brennan-Horley, 2019). Due to the research focusing upon digital engagements, it was also important to consider the effects self-surveillance and self-quantification can have upon both male and female participants, such as weight (Schofield, Thorpe, and Sims, 2021; Raggatt *et al.,* 2018), time allocation within familial relationships (Janzen and Cousins, 1995; Nomaguchi and Biacnchi, 2004), and the potential for exercise addiction (Baker, Griffiths, and Calado, 2021). As the research progressed, participants were chosen to ensure that the gender demographic was represented and to fill the gaps that arose during the analysis process.

The pursuit of cycling encompasses many different disciplines - road cycling, mountain biking, gravel biking, cyclo-cross, downhill mountain biking - that take place in different settings and use different types of bikes. Though each discipline is different, the technology used, aside from the bikes, remains the same. As such, using the varied types of cycling is not an effective means of stratification. Not only this, but it is also commonplace for cyclists to take part in more than one discipline within the pursuit. Participants were asked what their preferred type of cycling was to determine how this may affect their use of technology; for instance, road cyclists talk about measuring their speed while working against gravity to get to the top of a hill or ‘climb’ in as faster time as possible, whereas mountain bikers, working with gravity, want their time to be faster descending a technical part of single track. It is worth noting that asking cyclists how they would define their ability as a cyclist often elicited modest answers aimed more at how they perceive their ability to react to traffic and bike handling. Interestingly, cyclists that took part in different disciplines often used weather conditions as a factor in deciding what cycling activity they would take part in notably taking part in mountain biking when it is raining.

The area of sampling was initially set locally to the Peak District National Park and the surrounding cities. As the research progressed and the sampling continued the area was widened as participants were recruited often by word of mouth, or by meeting outside of the research and showing interest in participating in the research. As the sampling continued during the 2020 COVID-19 lockdown the sample area was once again widened to include cyclists based around England with interviews taking place online via video and voice calling applications. During the initial stages of the research, cycling clubs were contacted to recruit members, however there was either little or no response. As a result, more participants were sought through individual interactions with cyclists out and about and later through online forums and social media such as Facebook, Instagram, and Twitter. Facebook Groups were useful for contacting and reaching a large number of cyclists in a small amount of time. Personal contacts within the cycling community were also interviewed.

An initial questionnaire was used to inform the topic guides for the research. The purpose of this questionnaire was to gain an initial understanding in the use of cycling technology and ensure the design of the initial topic guide (Appendix 2) reflected this. The questionnaire highlighted themes within the research, such as familial conflicts, increased motivations, behavioural changes, and effects on their overall experiences of cycling. Respondents to the questionnaire were also asked if they would be willing to take part in an interview and, if so, to leave their email addresses. This resulted in five respondents becoming interviewees. Careful design was used during the creation of the questionnaire to eliminate and reduce any misinterpretations that can occur in self-complete questionnaires; questions were kept specific and targeted, and vague questions were avoided altogether (Bryman, 2008; McLafferty, 2010). Questions were aimed to be varied to elicit a breadth of information about the use of technology and applications for further use in other research methods but also to maintain the interest of the respondents (Bryman, 2008; McLafferty, 2010). The result of the questionnaires, along with the author's own positionality, meant that the resultant topic guides were a good starting point for the initial interviews.

5.3.1 Semi-structured interviews

The research was based on the use of practice theory to examine how people, technology, and practices coevolve (Shove and Walker, 2010). The use of practice theory provides an analytical understanding of changes that occur in practices that have (co)evolved through cyclists’ use of technology, looking at how their human agency is changed by inanimate objects (Dougherty, 2004; Ortner, 2006). This relates to the practices of cyclists (co)evolving with the use of ride and performance tracking technology and partner apps such as Strava. Strava has allowed cyclists to relive their cycle rides after they have happened through online virtual maps and trophies awarded for personal records or the completion of specific challenges; as a result of the digital and resultant gamification of cycling practices have changed to accommodate the competition offered online (Barratt, 2017). As Strava develops to attract new users it also develops to retain its existing user base and so continues to influence experiences of space (Hand *et al.,* 2007; Barratt, 2017). By examining practices within this research, it will help to identify why Strava has successfully become entrenched within many cyclists' rides and what the implications of this might be for policy objective around health and sustainability (Eden, 2016).

The theoretical approach to the research meant that semi-structured interviews worked well in understanding the relationships between the participants and their digital counterparts (Ortner, 2010). This research sought to understand the (co)evolution of cyclists and technology through understanding the changes to their practices through the narratives of those involved. As such, a qualitative methodology allowed the research to "unpack the mechanisms" driving the change through the participant's own experiences (Barbour, 2014: 14). As previously outlined, the positionality of the researcher was taken into account during the development of the methodology to account for any reflexive effects on the research (Barbour, 2014).

The research focused on exploring the blurring lines between digital and real-life experiences through the use of Strava and GPS devices. This was achieved by addressing the experiences of cyclists and examining the manner in which they interact with the real and digital worlds both during and post-ride. This meant that the research relied upon how the user perceived their own relationship with their digital technologies. At the start of the interview process, the interviews were open and conversational around themes developed for the purpose of the research; later, during the interview process, the interviews started to focus on the participant's narratives and their experiences while still remaining open and conversational. This adaptation over time helped to develop the understanding of (co)evolution amongst cyclists and their technology, and the growth of the digital world.

Semi-structured interviews allowed for a more conversational approach, each interview developing in different ways depending on the participants' experiences. It also allowed for the development of a discussion around the topics of research rather than a call-and-response style that would have occurred from a questionnaire or a more structured interview (Longhurst, 2010). This conversational style allowed the participants to raise topics that may not have already been anticipated and to allow for deeper probing of certain topics to gain rich and detailed data (Longhurst, 2010). The interviews were loosely structured by topic guides. This allowed the interviews to remain on topic but also allowed the freedom and flexibility for the conversation to divert off-topic if necessary, allowing the participants to explain the mundane or complex experiences in more depth (Bryman, 2002). This freedom allowed for the research to elicit richer insight or a greater understanding of the participant's responses and frame of view. As the interviews and research progressed, the topic guides were refined and revised based on the experiences of the previous interviews (Appendix 3). These revisions allowed the research to develop emerging ideas and gather insight into not only the niche but also the wider surrounding areas of the research. The conversational style also allowed the participants to feel more at ease while sharing their personal experiences and insights into their personal cycling habits and practices without stifling any of their tangents.

Name	Age	Gender	Preference
Leo	19	Male	Road Cycling
Jacob	22	Male	Road Cycling
Liam	24	Male	Road Cycling
Craig	25	Male	Gravel Cycling
James	25	Male	Road Cycling
Charlie	26	Male	Mountain Biking
Lucas	27	Male	Road Cycling
Brian	34	Male	Road Cycling
Phil	35	Male	Road Cycling
Reece	39	Male	Mountain Biking
Krish	40	Male	Road Cycling
Alex	43	Male	Road Cycling
Neil	44	Male	Mountain Biking
Oliver	46	Male	Road Cycling
Ben	47	Male	Road Cycling
Ryan	51	Male	Road Cycling
Max	52	Male	Road Cycling
Aaron	53	Male	Road Cycling
Matt	55	Male	Road Cycling
Greg	57	Male	Road Cycling
Jack	60	Male	Road Cycling
Bill	61	Male	Road Cycling
Robert	63	Male	Road Cycling
Chloe	28	Female	Road Cycling
Emily	28	Female	Gravel Cycling
Poppy	30	Female	Road Cycling
Jess	36	Female	Mountain Biking
Olivia	37	Female	Mountain Biking
Sophia	40	Female	Road Cycling
Debbie	44	Female	Road Cycling
Martha	59	Female	Road Cycling
Ava	59	Female	Road Cycling
Laura	59	Female	Road Cycling
Rory	30s	Male	Road Cycling
Gordon	50s	Male	Road Cycling
Archie	40s	Male	Road Cycling
Grace	30s	Female	Road Cycling
Freya	20s	Female	Road Cycling

Table 5.2 Sample details of cyclists interviewed. Pseudonyms have been used to maintain the anonymity of participants.

In order for participants to feel comfortable during the interview process interviews were arranged at the participants' convenience. Participants were able to select a time and a location for the interview to take place, this allowed for the participants to feel at ease and remove, where possible, any power imbalances between researcher and interviewee that may arise based on location. As a result, interviews often took place in the participants' homes. A small minority of the interviews were held at the researcher's home and office at the university. During interviews at participants' homes, there were occasions when the participant would collect a piece of technology or cycling kit they were referring to; this often helped them to talk about the kit and aid their answers. Before the interviews started, there were often conversations about cycling, training, and the pursuit that took place. This occasionally led to a tour of the participants' "pain cave" (a room at home where indoor rides or training takes place) or a tour of their current selection of bikes.

Throughout the interview process, subtle changes were made to the topic guides; these were often in the form of alterations to the wording of particular questions. This occurred from experiences of questions being misinterpreted and prevented the same misunderstandings from happening in further interviews. There were also questions that sometimes needed further explanation; these particular questions were often explained in as simple a way as possible to avoid leading the participants towards a particular answer. These changes and developments throughout the interview process prevented any assumptions from being made about the participants' frame of reference.

The evolution of the topic guides was another development that happened throughout the duration of the interviews. At the beginning, the topic guides consisted of three topics of questions. Starting off with 'Background' questions about their time cycling and their current experience before moving on to questions about the 'Digital Technologies' they used, and lastly, the interviews focussed on the participants 'Behaviours'. As the interviews progressed, the topic guide developed and changed to include more specific and in-depth topics. The new topic guide still started with questions about the participants

‘Background’ in cycling; however, the following topics were more specific in their focus and were designed to elicit more specific responses and narratives of personal experiences. These new topic guides were: ‘GPS Devices’, ‘Strava: Features, Metrics, Social, and Relationships’, ‘Behaviour: Stories from Cyclists’, and ‘Zwift / Virtual Platforms and Gamification’. The topic guides helped drive the overall process of data collection by keeping the interviews on track, but the conversational style of the interviews allowed for the research to develop and adapt throughout the overall process.

5.3.2 Narrative interviews

An additional purpose of the semi-structured interviews outlined above was to explore the biographical narratives of the interviewees and their experiences with technology. A result of these styles of interviews put the respondents at the centre of the research along with their experiences and stories (Anderson and Kirkpatrick, 2015). Due to the research focusing on the development of cyclists’ practices, it was important to “ask the how? why? and what?” (Anderson and Kirkpatrick, 2015: 1). Narrative interviews, in particular, afford the research a window through which researchers can contextualise and understand such how practices change (Barbour, 2014). While narrative interviews can focus on the telling of biographical life stories of participants, the goal of this research was to focus on specific experiences within that life history and gain personalised accounts of cyclists.

This focus on the personalised accounts of cyclists was key within the interviews. Respondents were allowed to speak freely with their answers, with non-verbal cues from the interviewer (Anderson and Kirkpatrick, 2015). Active listening was another key component that ensured the interview gained more detail from the responses when necessary. This also led to the interviewees controlling the pace of the interview. In some cases, interviews focused more on certain topics than others. Along with this, it was key to not intervene with the participants during their narrative (Anderson and Kirkpatrick, 2015). An important part of the narrative interview process was ensuring participants were not interrupted during their process of speaking; at times, this could result in long pauses to ensure the respondent had finished speaking. At times, it was not always clear whether the response was over, and in such instances, the interviewer could interrupt the interviewee – in these cases, it was important to let the interviewee continue and finish their response (Anderson and Kirkpatrick, 2015; Muylaert *et al.*, 2014).

Barbour (2014) notes that the structure imposed upon narrative interviews is decided to an extent by the researcher. For this research, the context of the interviews was more focused than other forms of narrative interviews where the interviewee can more freely decide what aspects of their lives to tell or leave out. The topic guides outlined for the purposes of this research facilitated the situated and detailed accounts of cyclists (Barbour, 2014). The interviewers' experiences of cycling allowed for a deep and rich understanding of the responses from interviewees and allowed for deeper probing when necessary (Atkinson and Kirkpatrick, 2015).

5.4 NVivo and inductive analysis

Raw data in the form of interview transcripts was inputted into NVivo. The processing of the interview transcripts was aided by the NVivo software. NVivo allowed codes to be created from the raw data and be seen across all the uploaded material. It has been argued that qualitative analysis software such as NVivo makes the analysis process easier with its "code-and-retrieve" setup (Fielding and Lee, 2002: 199). NVivo was used for the duration of the analysis process along with inductive analysis to avoid applying bias to the data and allow the participant's responses to speak for themselves. This resulted in the first round of coding to take on an *in vivo* whereby the respondent's own words were often used to identify the narratives of the participants without removing any nuance (Manning, 2017).

With the raw data uploaded to NVivo coding, the research began transitioning towards the analysis stage. As the analysis of the interviews began, coding was applied in a manner that allowed the data to remain free from any prejudgements that could occur from the researcher's positionality (Charmaz and Belgrave, 2015). This also allowed for the analysis to be "attentive to the ideas and terms invoked by respondents (Barbour, 2014: 265). Much like grounded theory, the analysis involved utilising *in vivo* coding that ensured the data could speak for itself without the application of preconceived ideas or bias (Crang, 2005; Manning, 2017). While a full application of grounded theory was not compatible with the later applications of practice theory, it maintained that the research was analysed in an inductive process whereby themes and codes were derived directly from the text (Crang, 2005; Manning, 2017; Vears and Gillam, 2022). Each code summarised the data and was named appropriately, often a short phrase taken from the text that was added to the code. For instance, codes relating to the information cyclists use while they are riding were coded as "during ride data". After five interviews had been coded, the codes were revisited. This allowed for the codes to be reviewed and ensured that no codes were being repeated (Vears and Gillam, 2022). This process allowed the codes to be clustered together into tree structures, allowing for the development of wider themes in the research.

As the coded themes emerged and all interviews had been through an initial round of coding the codes were again revisited. While maintaining an inductive approach to the data analysis, the codes were further subdivided. As Crang (2005: 223) notes, some codes "break down" where, although they are linked by a common theme, they have some distinct differences or nuances that also separate them. For Vears and Gillam (2022: 122), second and third rounds of coding allow broad themes to be further subdivided into more nuanced and "fine-grained subcategories". This process of coding and refining codes resulted in detailed hierarchical structures of codes, for example, the top code of "Strava", then branched into further subdivisions such as "App Script", "Self-driven", and then "increased motivation". After coding was completed, there were 393 parent codes in total; however, this fluctuated throughout the coding process as more codes were created and then merged or added to hierarchical structures as codes were periodically reviewed. Once coding was completed, the empirical analysis of the data could begin.

5.5 Ethics

Qualitative research can often encompass a number of ethical issues, this needed to be accounted for before the research process could begin. The research itself involved only adult respondents and was conducted in line with the university's ethics guidelines. Before the research began, a partial ethical consent form (Appendix 4) was completed and updated throughout the research process as different parts of the data collection started.

Ethical issues identified were:

1. Informed consent
2. Right to withdraw
3. Anonymity in the research
4. Explanation of how participant data and responses will be used

The issues identified were solved by the production of a consent form (Appendix 1) for each of the methods of data collection. At the beginning of the questionnaire, respondents could not progress until they had selected all the options and consented to the use of their data; for the semi-structured interviews, consent forms were handed to the participants to complete before the interview began. The consent forms included an overview of the project aims and an explanation of the participants' rights. Some of the responses throughout the research were personal in nature, pertaining to their medical history or spousal issues. For this reason, not only were the responses to be kept anonymous, but also for the research to be sensitive to the participants and how their data is handled while allowing them to continue with their narrative.

5.6 Summary

The process of interviewing cyclists was, at times, an entertaining subject. The narratives and stories from cyclists were, at times, funny, emotional, and occasionally shocking. During the process, cyclists took great pleasure in reporting their cycling achievements and highlighting the role technology plays in their practices. An advantage of a qualitative methodological approach allowed for the design of a research process that allowed the participants to tell their detailed, varied stories, and experiences of cycling. This allowed the research to gain a rich insight into their practices rather than the limited and inflexible structure that would have been imposed through other means of interviewing cyclists. Cyclists have been a proactive group of participants in the uptake of technology. Their varied history of self-quantification meant cyclists were particularly eloquent and eager to share their engagements and experiences.

The final sample of cyclists reflected cycling participation in the UK and provided rich qualitative detail for the study. Participants closely matched the diversity of cyclists in age and gender. Despite many of the respondents having similar experiences, and stories their motivations and uses of the technology were reflective of their own personal and cycling preferences. The interviews, research, and personal knowledge and understanding of cycling allowed for a successful implementation of a narrative interview approach.

The personal knowledge and experiences of the interviewer, coupled with physical, tactile prompts from the interviewees, allowed for deeper narratives of their technological practices. For some of the interviewees, having their technology on hand allowed them to recall particular experiences and memories of its use. At the beginning of the interview process, the interviews took place in the homes of the respondents where possible to allow them to feel more comfortable in their surroundings. Where this was not possible, the interviewer hosted the interviewees at their home. During the latter stages of the data collection, interviews took place online through video calls. While the nature of video calls allowed the research process to continue through the COVID-19 pandemic lockdowns, there were issues that arose from the process. Issues surrounding connectivity, call quality, and equipment not functioning properly. This did pose an issue at times, especially poor call quality, in understanding some of the interviewee’s responses. In these instances, where possible respondents were understanding and were often happy to clarify their responses.

The next chapters explore the socio-technical assemblages of cyclists through their narratives of digital creep. The empirical and discussion chapters use the information gathered through the methods outlined above. The empirical chapter separates the cycling assemblage into three distinct themes to identify a narrative of their emergent technological practices. While the discussion chapter explores the findings of the empirical chapter and their applications into wider themes of everyday technological practices and potential for future applications in active leisure and transport.

Chapter 6: Narratives of digital creep

> "I knew I wanted it for heart rate; that was a main, a big one. I wanted to know how far and how fast because originally, I got the watch because Strava Maps wasn't, at the time, recording very well, and my pace was all out. So, as soon as I got the watch it was really interesting to see how my pace went, how the distance was recording, and how my heart rate was recorded. And I also learnt how to do different activities and which screens I wanted for each one. So, yeah, I would say within a week, I was using it on every single run, and now ride, I don't go anywhere without it, and even now, I actually put it on when doing Pilates or like a workout just to see what my heart rate is doing because I've become part of that stats world." (Chloe, 28)

6.1 Introduction

This chapter represents the empirical work of the thesis and covers the following themes relating to research questions 1 and 2: how cyclists were introduced to cycling and how cycling takes on various meanings throughout their lifetimes, how the development of practices are mediated through technology, and how technology is contingent to experiences and (co)produced through their practices. These questions asked:

1. What do the narratives and lifecycles of socio-technical practices tell us about the technologisation of leisure practices?
2. How do cyclists' practices change: what are the mechanisms of this change and what are the consequences?

It has become increasingly accepted that everyday life has become mediated through technology and that such "phenomena have radically transformed almost every aspect of human life" (Ash, Kitchin, and Leszczynski; 2019: 1). For Kitchin and Dodge (2011: 3) "software has become the lifeblood of today's emerging information society" transforming mundane everyday objects and making them increasingly codified and capable of tracking the lives of people that use them. For many of the interviewees, technology has become an integral part of their cycling routines and rituals. Cycling is a hybrid assemblage consisting of the cyclist, bike, and requisite technologies of individual riders. While the bike enables the physical act of cycling, this research focuses on the digital technologies and applications that extend and (co)produce the ephemeral aspects of a ride into tangible and relivable entities. The narratives collected from interviewees demonstrate an acute awareness of the effects technology has on their experiences and bike rides. In some aspects of their riding, technology is a focal part of informing their decisions and transforming their spatial interactions. However, despite it forming a focal part of their rides, the use of the technology is considered as normalised, routinised, and mundane (Shove and Southerton, 2000; Michael, 2000). The revelations within these narratives provide insight into how such practices transcend cycling into everyday leisure and active transport routines.

Cyclists' use of technology has produced routinised practices that affect and influence their cycling performances before, during, and after each ride. This chapter explores the relationships between cyclists and technology further. Developing upon the theoretical contributions within this field and building on work such as Leszczynski (2019: 15), who has:

> "become interested in examining and theorizing the spatialities produced with, through, and by digital devices, services, and content productions that have become expected and entirely ordinary presences in the spaces and practices of everyday life."

The rise in the prevalence of digital computing technologies and social media networks has necessitated the development of new theoretical frameworks to understand "the production of space and socio-spatial relations (spatiality)" (Leszczynski, 2019: 13). Technology has become an integral part of the production of space and is increasingly axiomatic within not only cycling but everyday life. While Jones (2014: 288) referred to GPS maps produced by technology as "falsely objective, cold and detached", this was not the case for the participants interviewed. Instead, the maps generated imbued them with motivations to ride more frequently (Barratt, 2017), gave them new means of social interactions with like-minded friends, and augmented their experiences through game-like features that reward users with digital trophies and medals. Lucas illustrates how technology and surveillance become interwoven into the practice of cycling:

> "It sounds a bit sad, but I kind of, now I know where the segment starts, and you go right, so you might ride a little bit slower in the kilometre up to that segment so that I have a little bit more energy in reserve for the hill. Now, I don't think that has changed my ability of riding in anyway, but it is kind of almost a sub-conscious thing of 'Oh, this is the Holme Moss, but I'm gonna try and ride a little bit faster', and I think that's, I think that having that competitiveness against yourself is, for me, is a good thing. I like it because it drives me to be fitter, be faster…" (Lucas, 27).

The technologised cyclist is changed and enabled by the technology that is incorporated through their rides. The ride is no longer solely affected by the physical landscape but is (co)produced through a series and network of satellites, bodily sensors, and application scripts to form a socio-technical cycling assemblage. Like the quote from Lucas (27) above, technology affects cyclists' interactions even when they do not necessarily perceive such changes.

Given that everyday life has become permeated with and mediated through technology, the following sections in this chapter examine how cyclists and their technologies have (co)evolved into their socio-technical assemblages. Using cycling as a case study, the research "reminds us that relevant elements need to co-exist if practices are to extend or endure" (Shove, Pantzar, and Watson, 2012: 57). Cycling and the experience of cyclists is contingent on the presence of digital technology whereby cyclists will wait for a device to charge or return for a device they have left behind. The cyclist is an assemblage of distinct technologies that "demonstrate the heterogeneous connectedness of entities" (Michael, 2000: 2). While Michael's (2000: 2) was referring to "nature, culture, the human body" as entities, it is pertinent that in modern society the digital is considered as an entity entwined with social life and practice. The interconnectedness of technology and everyday life meant that there are forms of association present that helped to facilitate the development of cyclists into socio-technical assemblages (Shove, Pantzar, and Watson, 2012).

The approach to this research examines how cycling is digitally mediated through technology but also how such digital mediation becomes subsumed into the practices of cyclists and how their experiences are contingent upon the incorporation of such technology. This chapter examines these relationships and connections that are formed by cyclists with their technology and relates their narratives to the theoretical frameworks outlined in Chapter 4. This means that there are recurrent themes throughout the chapter that aim to articulate cyclists' digital engagements through the everyday practices of cycling.

6.2 Structure of the empirical chapters

This chapter presents and examines the narratives given by cyclists through the course of the semi-structured interviews. While there are areas of overlap that occur between cyclists and their uses of technology, the chapter has been divided into three separate themes surrounding the practices of cyclists and their technologies. First, the chapter explores how cyclists were introduced to cycling. This section examines how the meanings and associations of cycling change over time, presenting cycling as a pursuit that can take on various meanings throughout a cyclist's life with changing wider assemblages and practices. Second, the mediation of cycling practice is examined through the development of technology. Technology has developed and changed; this has led to cyclists changing their habits and cycling assemblages. Technology and practice (co)evolve within what, at times, appear to be fluid assemblages. Finally, the socio-technical assemblages of cyclists are explored and the impacts the technology has upon their real-world experiences. This demonstrates how the cyclists' experiences have become contingent upon the presence of technology and are (co)produced through practice.

The production of cyclists

6.3 Introduction

The pursuit of cycling plays an important part in many people's lives. Cycling practices change and develop through individuals 'cycling careers'. The interviewees described how they drifted in and out of cycling through their lives with prior experience, often driving a reinfused passion later in their lives. Cycling represents not only a form of active leisure and exercise but is seen as a means of freedom, a mode of transport, and, in some instances, "a way to escape" (Craig, 25) from the other pressures of daily life. For many, the practice of cycling has become (re)shaped and (re)configured through a range of socio-technical developments; notably, there are GPS-enabled cycling computers and applications used to log the data with software scripts that augment the ride. The cyclists who were interviewed, particularly those with a history in the pursuit, identified as mobile digital technologies, had become more prevalent. These technologies had crept into and changed the pursuit of cycling. To understand the changes that have taken place and what drives contemporary cyclists, it is important to understand their initial motivations. This context starts pre-digital and provides a foundation for exploring how technology has become entwined within the practice through a process which will be termed 'digital creep'. This first section will explore when and why cyclists started cycling and, in some cases, how they came to *'get back'* into cycling.

6.4 The act of independence

As Noreen McDonald (2012: 235) states, "learning to ride a bicycle is an important milestone for children". The act of cycling as a child can bring with it a newfound independence, the ability to travel farther away from home than previously able. In his book's opening remarks, Herlihy (2004: 1) reflects on his first experiences of cycling "wobbling beyond the clutches of an anxious parent". He recounts the freedom to travel "wherever your spinning feet could take you" and that the act of cycling "was indeed a true love affair" (Herlihy, 2004: 1). While for some, cycling remains an act that they take part in throughout their life, both for utilitarian purposes and for leisure, for others cycling gives way to faster means of transport. Turning of age to drive often coincides with the subsidence of bicycle usage along with a number of other life events that can also trigger changes in how much cycling people take part in (Chatterjee, Sherwin, and Jain, 2013). In some instances, the arrival of children can have an impact on the amount of cycling parents take part in. While for some, cycling is increased due to taking part with their children, those that regularly take part in cycling can drastically reduce the amount they cycle. The associations that are made with cycling from a young age can have profound effects on how the practices of cycling are further moulded later in life, especially as more external commitments come into their lives.

> “Learning to cycle is an important milestone that has important implications for future life. Across many cultures, the use of bicycles is the first personal active traveling behaviour for children to extend their territorial scope, ranging from home to school and other meaningful places” (Cordovil *et al.,* 2022: 2).

As mentioned above, many of the respondents in this research learned to cycle as a child. For some, the practice was carried on throughout their life, whereas for others, life simply got in the way. There are a plethora of ‘how to’ guides on the internet on how to teach children to ride a bike, some claiming to take as little as 30 (Beach, 2021) or 45 minutes (Charlton, 2022), as well as step by step guides to riding without stabilisers (Sustrans, 2019). It is apparent that when recounting learning to cycle, there is a reoccurring theme, a “biographical journey” (Cox, 2019: 2) that starts as an extension of play and mobility independent from parents (Cordovil *et al.,* 2022; Cox, 2019). Mercê *et al.* (2022: 12) found that children who learned to cycle from an earlier age develop their “social and emotional skills”. Cox (2019) also credits cycling with the development of new skills, both physical and social, as he traversed his extended world and navigated the behaviours of others on the roads.

During the interviews, the cyclists were asked how long they had been cycling for and how they entered the pursuit. While responses were varied there was some consensus among them. Some cyclists gave brief answers like Matt (55), who responded, “since I was probably about three”, or Leo (19), who succinctly stated, “competitively since I was 13, regularly since I was 9”. However, some of the cyclists recalled fond memories of learning to ride a bike and the freedom that came with it. Oliver (46) recounts memories of his childhood and visiting friends on his bicycle:

> “right from when we were little kids, we had bikes. We grew up on a farm, and so we, our friends, our nearest sort of good friends, lived a mile away, and […] the only way to see each other was to cycle up and down to each other, or walk, but it was quicker to cycle.”

Like Cordovil *et al.* (2022) and Cox (2019) stated, the ability to cycle at a young age enabled Oliver to further develop his social skills as well as facilitating play with his friends and extending the reach of his own mobility. For Oliver, looking back on his earlier years of cycling allowed him to recount fond memories of living on the farm and “playing games with my brother” and trips into Wigton to “trade in my bike for another … [bike] the next size up”. Cordovil *et al.* (2022), Mercê *et al.* (2022), and McDonald (2012) referred to cycling as a “milestone” in a child’s life. Similarly, Eva (59) referred to cycling as a “rite of passage” before expressing how cycling “was a good way for me to be independent if you like and, and [to] get away from the parents”. Eva and Oliver were not alone in their experiences utilising their newfound skills to explore areas close to home, much like Reece (39), who grew up in a small village where cycling was “pretty much the only way to get around” as a child.

Much like Oliver, Eva had a “succession of bikes” as she aged and outgrew the last. Cycling allowed Eva to explore the nearby countryside with friends, though such exploration did not always go to plan, as she remembers:

> “It was quite easy to get out into the countryside, so we went on a few little adventures. Doing that, you have experiments and a few punctures

> a long way away from home and [have to] ring my friend's big brother to come and fetch us in the car."

Much like Eva, other interviewees disclosed adventures of exploring the local countryside or growing up in small, rural areas where cycling "was the only way of getting about really" (Bill, 61). These responses support Cox's (2019: 2) "biographical journeys" and Herlihy's (2004) "love affair" with cycling. However, throughout the responses, the interviewees remember their experiences, experiences that were facilitated by technology, a mundane object that fades into the background. Learning to cycle as a child allowed the bicycle to fade into the background, the material object that allows new practices to emerge (Miller, 2005; Shove, Pantzar, and Watson, 2012).

However, much of the contemporary research fails to recognise the changes taking place and practices being developed during these formative years of cycling. As the bicycle itself is not an evident part of these narratives, it is, however, an integral part in the (re)production of practices (Shove, Pantzar, and Watson, 2012). With each and every (re)enactment of cycling, the practices are further subsumed into the practitioners prompted by mundane objects that "remain peripheral to our vision and yet determinant of our behavior" (Miller, 2005: 5). These early experiences of cycling lay the groundwork for further cycling practices to develop and endure throughout the respondents' life. The research goes on to recount these experiences and help practitioners reflect upon the changes to their practices brought about by digital cycling assemblages.

6.5 Cycling for utility

Bicycles have been a significant invention in modern history. They have provided people with novel leisure activities during their early conception and, more recently, have facilitated autonomous modes of transport with the development of the safety bicycle. The bicycle is an extension of the body, facilitating a faster mode of transport than walking alone. It has been used to varying degrees since the late 1800s, particularly with the development of the automobile, cycling for utility saw a steady decline. For many people living and working in the UK, the primary mode of transport used for commuting is the car. However, there is a wealth of literature surrounding the use of bicycles as an alternative means of transport (Latham and Wood, 2015; Lovelace *et al.,* 2016; Aldred *et al.,* 2019). Much of the research focuses on the provision of better cycling infrastructure and improving overall health through cycling.

Although the overall investment to own and run a car has become more affordable in recent years, there were respondents that either did not drive or chose not to drive due to the expense. As a result, commuting to and from work by bicycle is not always borne out of choice but out of necessity. While Bill (61) developed utilitarian cycling practices from a young age as he "used to go to school on [his bike]" and carried this practice forward into later life, stating, "even in my employment in the past, I've cycled to work" even while owning a car choosing to use two wheels rather than four. Not all the respondents developed these practices from a young age. For some, the use of cycling for utilitarian purposes came later in life. While attending university, many interviewees used their bikes as their main means of transportation. As most universities in the UK are located within cities, cycling has become a favoured mode of transport for a number of participants. Travelling by bike was often quoted as being a more economical way of travelling around the cities whilst respondents attended university. As well as being an economical means of transport, it was also often quoted as being a faster means of getting from A to B. In some instances, cycling was used in conjunction with public transport for more distant trips, particularly when the respondent didn't drive. For Max (52), "the bicycle is one of the key ways I can get around, that and public transport".

Despite commuting by bike being an unconscious decision for some of the participants, this was not the case for others. Two of the interviewees found themselves pursuing cycling through purely utilitarian purposes. Liam (24) did not drive, and although public transport was a viable option, cycling to and from work was a more time-effective means of transport. Before learning to drive, Liam's time spent cycling "wasn't really for enjoyment. It was more to commute". Similarly, Craig (25) also started cycling to work out of necessity:

> “I moved out of Stafford and Stafford is where I worked. So, I moved out to a small village about seven miles away, I don’t drive, so I needed some way to get to and from work, so it was for commuting purposes.”

Although cycling is often wrongly assumed to be used more frequently by those without access to a car or the ability to drive, Horton, Rosen, and Cox (2016: 6) state that “car-owning households are more likely to generate cycling trips than households without cars”. Jack (60) started to cycle to work because “it seemed silly to get in the car” to travel the five miles from his home. In some cases, respondents had either sold or were trying to sell their cars. Phil (35) started commuting to work one or two days a week initially before he realised he “hated sitting in traffic”, which quickly turned into a daily practice. The result meant Phil:

> “[S]old my car just over a year ago to use my bike more. … [T]hen in the end you know I was paying for a car that was pretty much sat there doing nothing so yeah, I may as well just get rid of it.”

Emily (28) was in a similar position to Phil, using her bike as her main mode of transport while living within a city in the south of the UK. As she lived with her partner, she felt it was unnecessary to own two cars, stating that they “only use the car to go mountain biking”. Commuting by bike is a significant choice made by those that own cars. While active transport, particularly by bike, has been significant in both political and academic discourse in the last several years (for example, Latham and Wood, 2015; Lovelace *et al.,* 2017; Aldred *et al.,* 2019), unlike in countries such as the Netherlands the UK has considerably lower levels of cycling uptake particularly for transportation (Horton, Rosen, and Cox, 2016). Cycling to work also has the added benefit of improving the health of the practitioner while performing what would otherwise be another mundane task of everyday life (Hendriksen *et al.,* 2010; Burgess, 2013; O’Hern and Oxley, 2015).

Although not all of the respondents used their bikes to commute to work, the majority of them actively looked to reduce the number of trips taken by car. For some, commuting to work by bike was not a viable option, as Charlie (26) states:

> "In terms of replacing car journeys because of the nature of my job, so cycling to work or running to work is just a different ball game for me. I've not got a fixed base, I'm all over the region."

Alex (43) also considered that if he worked in an office, he would cycle into work "without a doubt". Even though commuting by bike is not something that Alex takes part in, he does consider the journeys that he makes by car, often choosing to use the bike instead. This theme was presented by several interviewees, who would consider whether the car was essential to a journey and whether they were able to travel by bike instead. For some, this meant taking small trips to see family and friends in neighbouring villages like Poppy (30) and Eva (59), or using the bike to go into their nearby town or to the shops like Bill (61) and Laura (59).

During the interviews it was clear that not all the respondents had used bikes as part of their normal travel routines throughout their lives. Despite this the respondents cycling practices had started to develop and change over time. In some cases, it was the realisation that they disliked sitting in traffic, for others it was simply using their hobby to visit friends or complete a few errands. Health benefits and cost were quoted by a few interviewees, though they were not the driving factors for the majority.

6.6 Return of the cyclist

As mentioned above, cycling is a skill most appropriately learned at a young age. It was also clear during the interviews that many of the respondents learned how to ride bikes at a young age. Not all of those interviewed kept cycling from childhood. Much like Chatterjee, Sherwin, and Jain (2013) found there are number of events in a person's life that can prevent them from taking part in time indulgent activities such as cycling. This can be seen throughout the interviews; although reasons as to why interviewees took breaks away from cycling were not divulged, it was often discussed as to the reasons they started cycling once more. Time away from cycling also varied. It could have been as little as one or two years, but, in some cases, it was longer, such as 20 years.

Chatterjee, Sherwin, and Jain (2013) found in their research that the prospect of starting a new job often led to new opportunities to take part in cycling. Many of the respondents found themselves cycling to and from work through necessity. The change in their circumstances allowed them to evaluate their needs for transportation. Travelling only short distances to a workplace was unnecessary for some respondents, and others either lacked the ability to drive or there was no viable alternative, as discussed in the previous section; this was the case for a number of interviewees. What Chatterjee, Sherwin, and Jain (2013) fail to acknowledge, though, is that starting work can also be a factor in why people stop cycling. Charlie (26) was one such respondent whose new job saw his circumstances change. As mentioned above, Charlie started a new job with no fixed location (see section 6.5). He was unable to commute to work for this reason and stopped cycling altogether:

> "it died a bit of death for a couple of years […] I just stopped doing it, but then, recently, in the past year or so, I've started riding again more, which is great, really. I've always loved it and always done it [cycling]".

Charlie found himself returning to cycling because of his love of the sport. Cycling was a big part of his childhood and a big part of his family. Charlie had an uncle that was an Olympic cyclist, and he himself had "peaked" as a junior cyclist, reaching "19th in the National Champs in Dalby Forest".

In recent years, cycling has become much more popular in part due to the success of British cyclists in both the Tour de France and the 2012 Olympics. The popularity of the sport grew, and saw an overall increase in the number of people participating in the year after. Jacob (22) found himself influenced by the Olympics and Tour de France, stating he "was one of those 2012 bloomers”. The increased media output of cycling during 2012 and subsequent years was mirrored with an increase of bicycle sales (Grous, 2012). Much like Jacob both James (25) and Phil (35) were influenced with the increase of televised cycling. However, this was not the driving force for them to start cycling. A decline in personal health or seeing peers with health issues was found to be a life event that triggered people to start cycling (Chatterjee, Sherwin, and Jain, 2013). Wanting to increase his fitness, James turned to cycling as he “quite like[d] watching it on the tele” and “needed to get fit [cycling] seemed like a good way to do it”. The impetus for James to pick cycling to get fit was due to seeing his dad and close friends cycling, whereas for Phil, choosing cycling was due in large to seeing it on television. Phil remembers:

> “I was getting a bit unfit, I knew I was getting unfit, you know, I was a smoker, a drinker, and… just kind of watching that [cycling] gave me a sort of kick to… go on a bit of a fitness thing and as I was watching the cycling it was just ‘OK let’s start doing that.’ That was it really.”

Cycling to improve fitness has been covered extensively through media outlets, particularly online and in print cycling magazines. The health and fitness benefits have also been covered widely within an academic context (Kaczynski and Henderson, 2007; Hendriksen *et al.,* 2010; O’Hern and Oxley, 2015). It is worth noting that during the research, the COVID-19 pandemic took place, and an increase in cycling was observed again. Even though cycling was a sport that came into demand during this time due to society within the UK becoming more health conscious, this was only cited as the reason for getting back into cycling once. Aside from Poppy (30), who has “really gotten into [cycling] since lockdown”, the remaining interviewees were already actively taking part in cycling before the COVID-19 lockdowns were put in place. Similarly to the COVID-19 pandemic, Martha (59) was an avid walker until an outbreak of Foot and Mouth caused a lot of the local footpaths to be closed. This resulted in Martha buying a bike to continue exercising outdoors. There was also an array of other reasons that caused participants to start cycling for instance Brian (34) was preparing for a Triathlon in an attempt to ‘broaden’ the sports he took part in. Another participant started cycling due to an accident occurring in another sport:

> “[R]owing was my big thing at uni, but I was injured in a boat crash, and then did all my rehab on a static bike. So, I thought, ‘well when I’m, when I’ve quit rowing, I’ll, I might give cycling a go.” (Olivia, 37).

Lucas (27), however, started cycling due to work. Unlike in the previous section, this was not due to a change in transport circumstances but because he is an outdoor instructor. During his employment at an outdoor centre, he was required to deliver Mountain Biking courses. Lucas started mountain biking out of necessity to improve his own skills, so as to effectively deliver his mountain biking courses.

During the interviews, there were varied reasons that led the participants back to cycling. Many of the respondents were already active and found cycling to be a means to improve their health further or as an activity to do during days of rest. In some cases, cycling replaced their previous activities as their primary sport. Having previous experience taking part in sports on a regular basis helped to form new cycling practices and allowed them to become part of the respondents’ routines (Shove, Pantzar, and Watson, 2012). Some of these newly developed practices and habits were also caused by changes in the circumstances of their lives, whether that be through injury, the pandemic and risks to public health, or a commitment to improve their own health, sentiments that are also reflected in the research conducted by Chatterjee, Sherwin, and Jain (2013).

6.7 Self-perceptions, competencies, and meanings

Cycling is a practice just like any other that is subject to the constituent parts working together to help said practice endure over time. While the meanings of the practice may change over time or disappear completely due to external events in life, it is clear that requisite skills and competencies remain. At the beginning of this chapter, the research looked at how learning to cycle as a child allowed feelings of freedom and extending their world to become imbued on the pursuit of cycling. Ascribing such meanings as freedom and fun to the mundane object of the bicycle while understanding the relevant abilities and competencies to cycle allow the practices of cycling to emerge by linking these elements together (Latour, 2000; Shove *et al.,* 2007; Shove, Pantzar, and Watson, 2012). For some participants, these meanings were cultivated and developed as their lives progressed, and the bicycle was used as a means of transport and to travel to and from school or university and later to work. Meanwhile, for others, the meanings associated remained those of childhood freedom, and in such cases, they ceased to perform the practice of cycling, causing the practice to become dormant until later in life.

The length of time interviewees took away from cycling differed, though it was clear that the relevant competencies remained. The know-how and skills learned as a child to balance and ride a bike enabled them to return to the practices at a later point in time. This had many driving factors, as seen in the previous section (6.6). These factors were the new meanings participants gave to cycling, the catalyst that allowed their practices to (re)emerge. Just as meanings are transformative and can bring practices back into practitioners' everyday lives so too are competencies. The skills acquired as a child remained throughout the years, allowing participants to quickly return to cycling after taking time away. When talking about their perceived abilities as a cyclist, many were modest and often understated their ability as 'average'. Even those who considered themselves 'experienced' were still humble about just how 'experienced' they were. Both those returning to cycling and those who continued to cycle throughout their life had developed their abilities recreationally and also developed new competencies for dealing with increased volumes of motor and commuter traffic.

Traffic was factored into respondents' perceived abilities. Perceptions towards safety have also been a context for much academic discourse in recent years (Sanders, 2015; Aldred and Crosweller, 2015; Aldred, Woodcock, and Goodman, 2015; Aldred, 2016). This is for good reason; motorised vehicles play a large part in all fatal road incidents with cyclists. Between 2015 and 2020, there were 643 cyclists that were killed during road traffic collisions, 83%

of which were involved with one or more motorised vehicles (Department for Transport, 2021). Many of the respondents felt comfortable riding their bikes and considered themselves confident road users. However, some nuance is needed to understand how confident some of the interviewees felt while riding on the roads. Reece (39) considered himself a confident cyclist, particularly around local trail centres, stating he can “handle blue and red trails”. This confidence was also mirrored when asked about cycling on the road, where he stated riding “on the road is fine”. A large part of cycling on the road involves cyclists encountering a large number of motorists during each ride; for Reece his feelings about traffic were somewhat contradictory due in part to a road traffic collision a friend of his was involved in:

> “I am happy with traffic, and riding in traffic is perfectly OK, but a friend of mine getting knocked off and being left permanently disabled, it worried me.”

The Highway Code Rule 204 states that, after pedestrians, cyclists are the most at risk from other road traffic (Department for Transport, 2022). It is therefore wise for cyclists to be cautious of traffic. A sentiment that Greg (57) agrees with:

> “I’m nervous about traffic, and I think you’ve gotta be nervous about traffic. And you must, must never be complacent, but yeah, I feel confident on the bike.”

Both respondents feel confident with their abilities on the bike but are still cautious when it comes to traffic. Navigating traffic is something that all cyclists experience at some point even the most avid mountain biking adventurers will experience a stretch of tarmac at some point in their ride. Though the avoidance of traffic was preferable for several respondents who would actively seek out routes with “less traffic along the way” (Krish, 40).

Despite traffic factoring into answers about perceived abilities for some respondents, it was not considered at all. Olivia (37) is a very accomplished cyclist with a full-time career; despite working full-time in a demanding job, she has raced in the UCI Mountain Bike World Cup. Olivia accurately described her ability as an “elite level” cyclist; although she expressed she was happy to have competed, she was pleased that she did not “make an idiot of myself on Red Bull TV”. Participants that took part in competitive racing had a greater perception of their own abilities, often referring to themselves as “experienced” (Charlie, 26), “quite a high-level cyclist” (Jacob, 22), or “advanced in comparison to most other[s]” (Leo, 19). Participants that did not take part in competitive racing were more reserved with their answers, often citing they were “average” (Robert, 63) or “Intermediate, not a beginner, but certainly not a pro in any sense of the word” (Lucas, 27). However, participants like Max (52) regularly takes part in Audax UK events, which see him cycle in excess of 200 kilometres during a ride.

> “I guess I’m a very experienced cyclist, and some people would think I’m a strong cyclist, but, you know, I’m not, you know, in terms, in relation to kind of club cyclists, I’d be pretty mediocre, I guess.”

Max was not the only person to compare his ability to “club cyclists”. Ryan (51) considered himself more favourably claiming his ability was “better than [an] average club rider” or Oliver (46) who perceived his own abilities comparable to an “average club cyclist”.

Despite technology being an important factor in many other aspects of respondents' cycling practices, it appeared very little when describing their abilities. As seen above, participants used real-world situations to quantify their own abilities. Several participants compared their abilities to that of “club cyclists”, while others used the completion of cycling events such as sportives. Those that completed such events often considered themselves “good cyclist[s]” (Aaron, 53), “pretty experienced” (Debbie, 44), or “very confident and fit” (Laura, 59). However, two comparisons were facilitated through the use of online digital applications. Strava was mentioned, in particular, by Greg (57) and Debbie (44). When asked about his ability, Greg stated:

> “From sort of, Strava, I’d put myself sort of two-thirds of the way up […] I’m usually in the top third, usually, usually about a quarter of the way down the lists of, of best times for things”.

Strava allowed Greg to convey his perception of his ability in quantifiable terms. Leaderboards on Strava are places of competition (section 6.15.1). Greg used the leaderboards in a similar way to those comparing themselves against club cyclists. Club cyclists are inferred to be of average or slightly above ability to beginner cyclists, whereas leaderboards are used as a spectrum with beginner cyclists at the bottom of the leaderboard, average in the middle, and experienced at the top.

6.8 Summary

This section has demonstrated that the requisite skills of cyclists are learned at a young age and associated with freedom and fun, a means to expand their accessible world. For some, the practice of cycling is carried on through adolescence and into adulthood, with the meanings changing over time and adapting to their current needs and situations. Respondents that took a break from cycling often returned with some sort of catalyst - there were a range of things that led them back to cycling from fitness, to transport, to injury rehabilitation. Each person had their new meanings ascribed to cycling, replacing those of their childhood. Therefore, the cyclist is realised not through the mere practice of cycling but the meanings ascribed to why they cycle, which enables them to keep (re)enacting the pursuit and prevent the practice from ceasing. Cycling as an adult is different and requires these changes to be made. These changes further highlight the complexities of the cyclist’s relationship to cycling practices; the ability for their meanings to change and seek new meanings allows their practices to be reconfigured and encompass new aspects of the sport. As this section has demonstrated, it is important to consider how the practice of cycling itself was formed within cyclists before the interactions of digital applications and devices are considered within their practices.

Socio-technical practices of cyclists are evolutionary being recast as practitioners return to the sport. Whether they began cycling for utilitarian purposes or started to improve their fitness, cycling has become a staple part of their exercise regime. The competencies learned as a child allowed respondents to return to the sport with relative ease. However, that is not to say there were no new skills to be learned. Cycling on the roads, especially as a commuter in periods of busy traffic, is a learned skill. This is an added complexity of cycling within the real world and is something that was not taken lightly by many of the participants. Traffic is a known barrier that prevents people from taking part in cycling, and something that respondents did not take lightly, noting that they were aware of the traffic around them. This research suggests that the practices of cyclists are susceptible to changes to the meanings associated with the practice itself. This presents potential for the abilities of cyclists to be influenced by other external factors that can affect their interactions with outdoor spaces.

This section has emphasised that while the practices are learned at a young age, they can be developed later in life regardless of whether breaks were taken in cycling. As cycling has developed in adulthood, respondents' perceptions of their abilities are compared to other quantifiable metrics. In some cases, this was compared to features available on digital applications or even the fact that they used such applications. While this section does not deal with the digitally mediated interactions of cyclists it is important to understand how the base competencies are developed within cyclists before the dawn of the digital era in cycling.

The mediation of cyclists

6.9 Introduction

This section now explores how the pursuit of cycling has become mediated through a number of constituent technologies. Some, like the bicycle, are imperative to the performance, whereas others enhance the experience. The previous section highlighted how the meanings associated with cycling have changed within the cyclist's life cycle. Understanding that cyclists' practices are fluid and adaptable helps the research consider how and why digital technologies are becoming an integral part of being a cyclist. Now, technology and the various roles it plays within cycling are considered. Using digital geography theories outlined in section 4.4, the research examines how technology is incorporated into spatial interactions of the participants (Ash, Kithcin, and Leszczynski, 2019) and how users can become "cognitively corrupted" (Michael, 2009: 1) or rather as this research suggests imbued with a "digital imperatives" (Barratt, 2017). As with much of modern life, cycling has become digital and digitised (Graham, 2013).

Technology plays an important role in how cyclists interact with the physical environments they cycle in (Barratt, 2017) and has been evident throughout the interviews whereby technology has become included as a part of pre-ride routines. These technologies have become integral parts of the cycling assemblage despite not being essential to the enactment of cycling. Participants used these technologies in varied ways – such as using in-depth training plans, for monitoring their performance during rides, or to track their progress over time. For all the respondents, technology formed part of their post-ride rituals, where they reviewed their performances and compared their efforts against previous rides. The sections below will outline how cycling technology has permeated into the "lifeblood" of cycling culture (Kitchin and Dodge, 2011: 1) and how it affects the spatial experiences that are "produced with, through, and by digital devices" (Leszczynski, 2019: 15)

First this section explores how technology has crept into cycling starting with what Greg (57) termed “dumb technology” – technology that is not connected to applications or GPS networks. While these technologies lack digital integrations, they laid the foundations that enabled digital technologies to become embedded within cycling practices.

6.10 Dumb technologies: enabling quantification

Before the introduction of GPS-enabled technologies and the first smartphones were released in 2007, the technology cyclists used was simple. These were technologies that were not connected to a phone or received location data through a global network of satellites. Despite this, they were more sophisticated than the rivet-based mile-o-meter Tommy Godwin would have used (see section 3.3.1). The use of such technology often reveals an insight into how cyclists’ practices have developed over time. Cyclists’ practices were shaped by these new technological devices mounted atop their handlebars. These early devices gave cyclists access to more information during their ride than they previously had. Respondents like Jess (39) spoke about cycling pre-technology and going out for a certain amount of time or specific distance, often over a known route:

> “the only thing I used to use was a stopwatch and go and do the same route and then go and see how much quicker I did, but, you know, you’re kinda half way along going ‘oh I don’t really know if I’m much quicker or if I’m not, or where am I supposed to be” Jess (39).

Olivia (37) also remembers tracking her rides through the duration. Despite having a small bike computer that tracked distance, Olivia would go “out for a set time because that’s all you could really measure”.

These early cycle computers varied in what information they could display and track. Speed and Distance were the most common features and were worked out by a magnetic sensor placed on the spokes of the front wheel with a receiver placed on the fork of the bicycle (Section 3.3.3). Martha (59) had a very basic computer that logged the distance and average speed she did and would "at the end of every month I just stick it [distance] in a spreadsheet" to keep a tally of her monthly and yearly totals. The ability to have distance recorded allowed respondents to quantify their rides and begin to track things like their total monthly or yearly mileage either in paper log books or in spreadsheets. As well as logging distances, many respondents remarked on the ability to track the speeds that they were achieving while riding. (Charlie, 26) remembers looking at the device and thinking, "Bloody hell, I'm going 30 miles an hour" as a teenager.

The use of these basic bike computers was, for many, an introduction to self-quantification (Lupton, 2014b). Cyclists tracked themselves with these computers in different ways. Some users, like Oliver (46), liked to "see the speed I'm going", while Jack (60) wanted to "see that I've, you know, increased my speed a little bit". Despite these computers being referred to as "cheap" (Neil, 44), "basic" (Olivia, 37), and "dumb" (Greg, 57), their uses are early examples of self-quantification. Many of the respondents were happy to use them to see how far they had ridden and for how long. By contrast, Greg and his friends used to use the devices to compete against each other: "Before I was on Strava […] me and my mates used to do some routes regularly and try and do them as fast as possible and time them". Similarly, when she started racing, Olivia tried to use one to assist with her training.

The past technologies and equipment that cyclists used has inspired and influenced the way they use technology within their cycling today. Although these technologies were 'basic' in comparison to the applications and devices they currently use, these bike computers were an introduction into the quantification of their cycling. While many users were content with seeing their overall speed and tracking their monthly distance totals, others were also introduced into the ability to compete and compare their efforts against their friends. This basic technology enabled participants to begin to quantify their rides. These early cycling computers provided the building blocks of self-quantification practices that would soon become digitised. For Charlie (26), however, he did not see the relevance of those computers, favouring instead to “just work it out on a map afterwards” and seeing such devices as “pointless” due to their lack of connectivity.

6.11 Cycling’s digital turn

There is no doubt that the early rudimentary bike computers of the previous section began the reconfiguration of cycling practices into a more technologised experience for those who used them. Cycling is a sport that is steeped in a history of technological alterations, initially to the machines cyclists rode but more recently into the devices and applications used to monitor their performances. In the early 2000s, society was becoming more connected with mobile phones, which allowed them to receive email and surf the web. 2007 saw the boundaries between digital and physical social interactions blur even more with the introduction of the iPhone. The production of the iPhone is significant to the technologisation because of Apple's development of the App Store. This saw the rise of third-party developed applications that made use of smartphone features, such as integrated GPS, to record the devices’ location. In the years since, smartphones have become a ubiquitous technology mediating peoples’ everyday lives (Ash, Kitchin, and Leszczynski, 2019), particularly for Millington (2018) due to the rise of fitness social media applications. The data from this research suggests that the motivations and habits of cyclists are (re)shaped and (re)configured through the use of digital cycling technologies. The smartphone, for many of the respondents, propagated a more digitally-mediated cycling experience. For the purpose of this chapter, the introduction of GPS-enabled cycling applications will be referred to as ‘*cycling’s digital turn’*.

6.11.1 An app to track

Self-quantification within cycling has a rich history. The Golden Book of Cycling catalogued various achievements like those of Tommy Godwin, outlined in section 3.3.1. Achievements like Godwin's were quantified through devices such as a cyclometer (Section 3.3.2) that counted each mile using a rivet mounted to the front wheel. Cyclists’ self-quantification practices have (co)evolved with the various technologies that have become available. This (co)evolution (explored in Chapter 3) shows how technology and practices were informed by each other. Practices have been redefined through each technological advancement. Rivet-based cyclo-computers were replaced by basic computers during the 1980s and 1990s, which in turn have been replaced by smartphone applications. The adoption and popularity of smartphone applications will be explored in the following paragraphs.

Much like the draw of being able to quantify their rides through the use of non-smart technologies applications gave cyclists the opportunity to visualise their rides in new ways. One significant difference between these new applications and the non-smart technologies was the ability to review and relive cycling performances after they have occurred, and as Barratt (2017: 330) states, “the bike ride is transformed from something that just happened into something tangible”. Although the use of applications to review performance was not completely new to cycling quantification, the introduction of smartphone apps certainly improved the user experience. Max (52) remembers trying to use a PC program along with one of his basic bicycle computers but found the experience to be “very clunky and quite difficult to use”. Out of the 38 respondents, Max was the only one who had any experience with these past technologies. Smartphone applications, on the other hand, were used by 37 out of the 38 respondents. Unlike Max, the use of smartphone applications was the first introduction to post-ride quantification of their bike rides for other participants. These apps allowed cyclists to focus upon particular aspects of their cycling after the ride had taken place and allowed them to visualise their rides. Users of such apps were able to see their routes laid out on maps, sinuously carving their way through the landscape. Map My Ride (Figure 6.1) was one of the first popular applications that allowed users to do this. As such, Map My Ride was, for many interviewees, their first foray into tracking their bike rides.

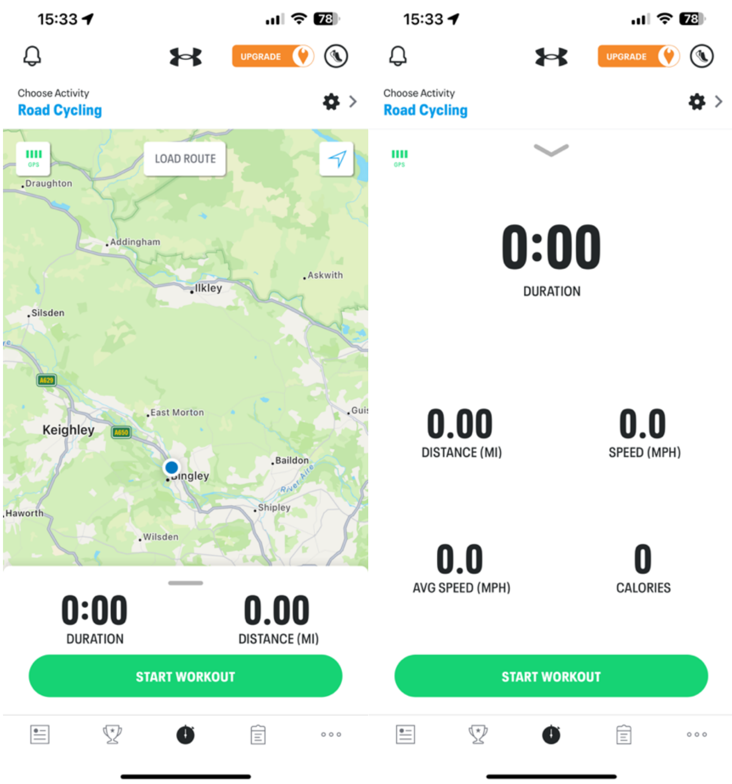


Figure 6.1 Screenshot from the Map My Ride application showing the ride recording screen and information display.

During the interviews, Map My Ride was referred to briefly by respondents before referring to other applications like Strava. Like Emily (28), who remembered, "I think I had a very brief foray with Map My Ride, that old chestnut". Early adopters to using applications found Map My Ride to be battery intensive and found that it was not able to record longer rides. For instance, Oliver (46) said:

> "When these sorts of apps came out on the phones the first one I that I used pretty early on, probably, was Map My Ride which killed the battery. It was a nightmare. You could only do about, I think it was, sort of, limit was about 30-mile ride, and you were pushing it then on the phone battery technology at the time."

Map My Ride remained a popular choice despite it having a negative impact on battery life until 2009 with the release of Strava. Strava quickly became a popular alternative to Map My Ride due to it having less of an impact on the battery life of smartphones. Strava allowed cyclists to record longer rides on their smartphones without worrying about their battery going flat. Oliver (46) remembers switching to Strava:

> "I used Map My Ride, Map My Run for quite a while until when Strava came out and then I switched over to Strava because it was much, much better on battery life and you could, and you could get it running for a much longer ride basically."

Strava (Figure 6.2) brought with it a new level of consistency to tracking rides. It enabled users to travel further and still record the entirety of their route. Cyclists like Oliver and Max had experienced the development of new technology throughout their cycling careers. They had become early adopters of new technologies and were no exception with the developments of smartphone applications and as cycling technology evolved, integrating it within their practices (Shove, Pantzar, and Watson, 2012).

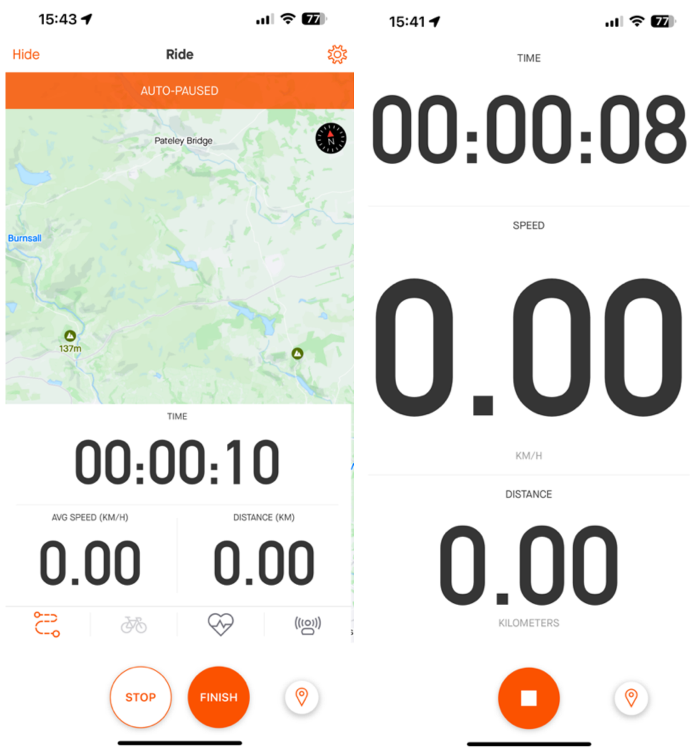


Figure 6.2 Screenshot from the Strava application showing the ride recording screen and information display.

Map My Ride (or Map My Run, an associated application focused on running) was used initially by respondents, particularly by those who had continued to cycle through cycling's digital turn. However, respondents who were returning to cycling after some time away from the pursuit - or those who were at the beginning of their cycling journey - Strava was their first experience of tracking rides. Strava had quickly become a popular application amongst cyclists. Much like the term "to Google" has replaced 'to search' (Heffernan, 2017: n.p), Strava had become a popular way for cyclists to share their rides and saw the birth of the phrase "if it's not on Strava it didn't happen" (Roberts, 2018: n.p). The popularity of Strava within cycling practices and the culture that surrounds it is seen among the interviewees. Respondents like Charlie (26) remembered Strava starting to become popular before he took a break from cycling: "Before I stopped, Strava was about, and I used it a little bit". When he returned to cycling a few years later, Charlie naturally started using Strava again.

Strava was also the first experience of ride tracking for younger interviewees and those who started cycling later in their lives. These respondents had not been cycling during the early stages of cycling's digital turn, and as a result, Strava had already become an established part of many cyclists' practices. Strava had replaced the non-smart technologies that came before it with new digital cycling practices. This has resulted in Strava being circulated amongst cyclists and even recruiting (Shove, Pantzar, and Watson, 2012) new cyclists at the beginning of their pursuits. With Strava being established and integrated by many into their practice, new cyclists like Debbie (44) are recruited through word of mouth. Debbie remembers being:

> "Told when I got my first, got my very first bike to go and have a little looksie and see what it was about, and I probably didn't get Strava for, for a little while so I used it without really understanding it." (Debbie, 44)

Unlike Max and Oliver, whose practices have evolved over time as new technology replaces old technology, Debbie started cycling with Strava as an important element within her cycling practices. Like Debbie, Sophia (40) also started using Strava through word of mouth. Sophia was a member of a club and joined Strava because: "People were talking about it in the club […], so it's also like a social connection with your friends". Sophia continued to incorporate Strava into her routines because it enhanced and extended the social interactions of the club post-ride. Strava provided users with the ability to interact with their cycling peers outside of riding with them through online social integrations such as comments and kudos. Like Sophia, Brian (34) also joined Strava “for the more social side of things”. These narratives show how cyclists are recruited into technological practices with little or no understanding and, through their continued use, gain an understanding and appreciation of the applications over time. This gradual process allows the scripts to influence their practices and (co)produce their experiences during each subsequent (re)enactment of the ride.

Word of mouth was a great way for Strava to build brand recognition amongst cyclists and other athletes, although not all cyclists were recruited by other users. Jacob (22) started cycling in 2012 but did not start tracking his rides until he joined Strava in 2014. Jacob started tracking rides “on my phone to start on the Strava app”. Self-surveillance practices had become routinised through smartphone applications like Strava. These applications helped ensure digital technologies had become integral elements within cycling practices. It is clear from the interviews that applications like Strava had brought about cycling’s digital turn – basic non-smart technologies were being replaced by smartphone applications. It was through basic technology being incorporated into cycling practices that enabled applications like Strava to become popular. Cycling practices were once again being transformed by new technological advancements. Oliver and Max’s cycling practices have been in a state of flux throughout their cycling careers, continually (re)shaped as new technology becomes available. Through the successful integration of Strava into the everyday practices of cyclists Strava began to propagate into the practices of cyclists (Shove, Pantzar, and Watson, 2012) newly embarking within the pursuit.

6.11.2 The limitations of Smartphones

The development of the smartphone and the introduction of applications was the catalyst for cycling’s digital turn. The prevalence of smartphones meant that they were, for 37 of the 38, respondents' first experience of using GPS-enabled applications. Applications like Strava became an integral part of cyclist's practices and formed a large part of the discussions within the interviews. Participants often focused upon the issues that arose through the use of applications to record their activities. The use of smartphones and applications was a new element that had become subsumed into cyclist's practices. Practices are fragile in their nature, and their existence is reaffirmed through each enactment. For Shove, Pantzar, and Watson (2012: 32) "practices involve novel combinations of new or existing elements […] [and] such integrations are themselves transformative". Applications like Strava play an important role in the transformation of cycling practices, which have (co)evolved with and incorporated these digital elements. As has been stated, the smartphone was the first experience many interviewees had with digitally tracking their rides. Once apps like Strava become embedded within their practices, users start to experience limitations of tracking through the smartphone app and become dissatisfied. Such dissatisfaction led to users seeking alternative ways to continue recording their rides while still incorporating Strava within their practice.

A popular frustration among the participants was the issue of battery life. Respondents lamented that running GPS applications on their smartphones was very battery-intensive. Better battery life was the main reason for users like Oliver (46) to initially start using Strava instead of Map My Ride. While Strava allowed users to record longer rides, it was still intensive on smartphone batteries. As Ryan (51) started recording his cycle rides through his smartphone, however, as his rides increased in duration, he realised "your phone battery is not gonna last". This frustration was shared amongst many of the respondents who reported uncertainties about whether the "battery life of your phone was never gonna last sometimes as long as your ride would [last]" (Craig, 25). Poor battery life has been widely reported through cycling magazines, online articles, forum posts, and even Strava blog posts. These online posts offered various solutions to extend the battery life of smartphones so users could record longer rides. Despite respondents being frustrated with the poor battery life, especially on longer rides, many continued to use Strava within their cycling practices. Ben (47) found that putting his smartphone into "aeroplane mode" extended his battery life and allowed him to continue recording longer rides.

Despite battery issues being a common theme amongst respondents, it was not the only issue that plagued their self-surveillance practices. There were also reports of GPS accuracy issues with their smartphone recordings, as Eva (59) elucidates:

> "I quickly found that I was frustrated with it because it didn't always, well, maybe the recording is the same, I'm not sure, but it seemed to me like the phone wasn't recording as accurately."

Eva enjoyed being able to see her progression through tracking her activities with Strava but was frustrated by her phone's GPS accuracy. Craig (25) also had a similar experience while using his smartphone:

> "GPS in phones aren't great anyway, or certainly the phone I had four or five years ago wasn't, you know, they did the job, but you'd often get an anomalous max speed, or you'd be going 150 miles per hour or that kind of thing. Your distance could be a bit off as well, or your elevations could be off."

Frustrations about GPS accuracy have also been publicised in cycling magazines, online articles, forum posts, and Strava blog posts. Such articles provide users with ways in which they can try to maximise their phone's GPS recording accuracy.

Shove, Pantzar, and Watson (2012) have demonstrated how, for the survival of practices, it is important that they are continually reproduced. In this regard, the frustrations felt by the respondents put digital cycling practices at threat as they could start to detract from their enjoyment. In one instance a respondent was frustrated by the negative impact Strava had on his smartphone battery he simply stopped using the application altogether, however, this was not the norm. Despite the issues above, Strava has become embedded within cyclists' practices. This was aided by Strava sharing relevant competencies and meanings associated with wider social media practices (Shove, Pantzar, and Watson, 2012; Ash, Kitchin, and Leszczynski, 2019). Furthermore, Strava allowed respondents to experience external satisfaction by uploading and sharing their rides with like-minded communities such as Eva (59), who “enjoyed being able to see progression”, or Emily (28), who enjoyed the “social aspect”. Both Eva and Emily’s references to self and social surveillance were mirrored throughout the other interview responses. Self-surveillance and quantification are important aspects within these cycling practices. Therefore, it is vital to explore how socio-technical cycling assemblages have continued to (co)evolve with Strava and overcome the frustrations that occurred through recording with smartphone applications.

6.11.3 Dedicated devices

Switching from smartphones to dedicated GPS devices was something many of the respondents did. The market for these dedicated devices is varied. Since Garmin released their first sports watch, the Forerunner 201, in 2003 (Garmin, N.D. d), the market has diversified. Devices can be broken down into two broad categories. The first are specific devices; these are aimed at one sport, for instance, bike computers like the Garmin Edge range (see Figure 6.3) that are purposefully designed to record cycling activities. The second category is multisport devices; these often come in the form of watches like the Garmin Fēnix range (see Figure 6.4). Multisport devices allow users to record various activities like running, cycling, swimming, yoga, and much more. The devices respondents chose to upgrade to often reflected what activities they took part in. For those that were primarily focused on cycling they chose to upgrade to a specific bike computer. Interviewees like Greg (57), who bought a Garmin Edge 510 so he could further analyse his rides:

> “Me and my mates used to do some routes regularly and try and ride them as fast as possible and time them. So, it’s nice to have some sort of little trip computer or something on your bike. And I, sort of, found out

that the Garmin Edge gave me a lot of, I like analysis on stuff, and you get a lot of analysis on there, and I was interested in heart rate and stuff like that, and it would monitor my heart rate, so I bought one".

Like other respondents, one of the reasons Greg purchased a dedicated device was due to the enhanced data collection he could have. Computers like the Garmin Edge range allow users to record biometric feedback like heart rate and display it in real time on the device. The device appealed to his analytical side, as well, allowing Greg to continue to record his times on specific routes. Upgrading to a cycling-specific dedicated GPS device also allowed users to transport their data from their back pockets (many cyclists keep their smartphones in a pocket on their jersey; see Figure 6.5). By having the information out in front of them they were able to immediately quantify their performances. This also meant that for Strava users like Jacob (22), "could see on the fly what I was doing" rather than having to stop and look at his smartphone.

Figure 6.1 Garmin Edge 520.

Figure 6.2 Garmin Fēnix 6.

Respondents who were keen to upgrade to a dedicated GPS device but also took part in other pursuits aside from cycling, like swimming and running, purchased multisport watches. Upgrading to a multisport device like a Garmin Forerunner or Fēnix also allowed users to transfer their data to a more accessible location. Wearers are now enabled to glance at their wrist and see real-time data and feedback such as speed, distance, and heart rate – like those with cycling-specific devices. Oliver (46), who purchased a Garmin Watch, explained:

> “I’ve been doing a bit more running. I got sick of carrying my smartphone running, and I got a new job and, so I thought I could treat myself. I’ve been wanting a Garmin watch for a while, and I also wanted something that I could use in the pool because I swim as well. So, I wanted something that I could use across all three disciplines and not have to bother faffing, so at the pool, up until then, I was using, at the Alfreton Leisure Centre, you can use these swim tags that they have and that then sends the data, you had to collect it and then hand it in again, and then it sends the data to a website and you see your performance on there but you can’t link that to Strava. And so, what you don’t see is, you know, your cumulative exercise.”

Oliver explained that he is not just a cyclist. His choice to purchase a multisport watch allowed him to record all his activities with one device. By purchasing the Garmin watch, Oliver was able to go running without having to carry his smartphone with him and still record all of his activities. It also meant that he was able to record his swimming without having to use the leisure centre's proprietary technology. Oliver also emphasised that having the watch allowed him to collate all his exercise in one place, Strava, and by doing so, he could see his cumulative exercise statistics.

Figure 6.3 Smartphone in a jersey pocket.

6.12 Summary

This section has shown how cyclists have become more technically mediated within their cycling. Technology has become subsumed within the practices of cycling and has become a constituent element that has survived and (co)evolved with cyclists. Practices themselves are fragile and susceptible to change, which has been clearly demonstrated through the interviewees' responses and their acquisition of technology. As a result, cycling has become transformed from an ephemeral experience into a relivable digital artefact that users can revisit through associated ride-logging applications. The technology respondents use is representative of their activity recording needs. Basic non-smart technology gave respondents the requisite competencies that enabled dedicated GPS devices to become recruited into the digitally mediated practices. Further highlighting how cyclists' technological practices have (co)evolved with various iterations of technology and how these technologies have begun to augment their cycling experiences. Understanding these initial progressions into socio-technical cycling assemblages is important to better understand how cyclists' practices change and what the consequences of these changes are.

The prevalence of smartphones enabled cyclists to become increasingly mediated by technology and has resulted in cyclists that are continuously connected (Wislon, 2014). Continuous connection through applications and technologies can (re)configure everyday practices of movement and mobility (Schwanen, 2019). New technologies that record their rides and provide ways of quantifying their performances will thus have an impact upon the practices of cyclists. This section has outlined the beginning of cyclists seeking to digitise their bodily functions and have them presented in meaningful ways (Lupton, 2014b; Millington, 2018).

These insights are crucial for understanding the effects technology has on other athletic pursuits outside of cycling. Technology is becoming increasingly incorporated into many different sporting pursuits. Once a dedicated GPS device becomes employed within the practice, the act itself becomes more susceptible to the influence of the real-time feedback provided. As Barratt (2010) suggested in his PhD thesis, the presence of technologies in the pursuit of sport can allow practitioners greater insights into their performance but can also corrupt their experiences during the pursuit's enactment. This research shows that as cyclists begin to use these technologies within their practices, they start to seek more information to analyse and understand their performances. This also feeds into Millington's (2018) idea of Fitness 2.0 and confirms the technologisation of sport whereby users are seeking ways to quantify their performance through instant feedback.

Although various dedicated GPS devices are available, their core purpose is fundamentally the same. Dedicated GPS devices are the hub of cyclists' socio-technical assemblages, bringing associated sensors and real-time data into an accessible location during their rides. The result of cyclists' digital practices is a tangible digital artefact that can be utilised post-ride to perform in-depth analysis and relive the experience. The next sections examine the various scripts and sensors that augment and mediate the cycling experience.

Bodies, Bikes, and Binaries

6.13 Introduction

Without technology cycling is an ephemeral act. Once the act is complete, there is nothing left but the memory of the ride. Rides linger in the legs, wear down the rubber of the tyres, and the cogs and chains become aged and worn. Throughout the years, various advancements have led cyclists to be able to quantify their rides. Early technologies like Avocets Cyclometer enabled cyclists to see real-time information and provide them with basic statistics of their cycle rides, such as average speeds and distances cycled. However, as the previous section highlighted, self-quantification has become increasingly digital. The network of technology extends beyond physical devices and into an array of associated applications. This section considers the role that these socio-technical assemblages of devices and applications play and how they influence the practices of cyclists. Applications are considered through the narratives gained from interviewees and combined with practice theory to understand what changes cyclists have experienced by incorporating such technologies into their practices. Contemporary research suggests that self-surveillance and quantification within the pursuit of cycling and other sports has become increasingly popular (Millington, 2018). Applications like Strava have risen in popularity due to its use of gamification to increase participation from its users (Barratt, 2017; Lupton, 2014b).

Ride-logging applications have become an important part of cycling culture, particularly Strava. Strava is not the only application that supports ride logging and provides users with the ability to analyse their rides. However, it is one of the more popular apps, with around 100 million people using the free app (Chafkin, 2022). The popularity of Strava, coupled with their dedicated GPS devices, was certainly apparent among the cyclists interviewed and formed an integral part of their cycling routines. Although Strava does not directly enable the practice of cycling, respondents considered Strava to be a valuable part of their cycling experience. While technology is present before, during, and after a ride, Strava forms a significant part of the post-ride experience and can be consulted at length by cyclists as they pore over every detail of their ride. This emphasises Barratt's (2017) notion that cyclists are becoming increasingly embedded within these digital cycling practices. This section will focus on Strava due to its popularity. Other ride-logging applications will also be discussed; however, despite different applications being available, they were not as frequently referred to during the interviews. This section will start by identifying the digital artefacts that are created using digital technology. To achieve this, it will examine why Strava is used and, what the artefacts mean to the users, and how these digital representations of rides are crafted and produced by the user to reflect more of their experience.

6.14 Digitising the ride

> "From economies to cultures to politics, there is almost no area that remains untouched by the digital techniques, logics, or devices" (Ash, Kitchin, and Leszczynski, 2019: 1).

Cycling, like nearly all aspects of daily life, is digitally mediated through technology. Particularly, daily social interactions have become increasingly common online through social media. Platforms like Facebook, Twitter, and Instagram allow users to consume and produce content to be shared through these online communities with friends and strangers who have similar interests (Ash, Kitchin, and Leszczynski, 2019). Strava, at its core, is an online social media focused on building "the most engaged community of athletes in the world" (Strava, 2022a: n.p). The research has shown that cyclists are technologically engaged and have become keen users of Strava. As discussed previously, rides are transformed into digital artefacts either through smartphone applications or by a dedicated GPS device.

Digital artefacts, or rides, are created by the cyclists who ride them. Its creation is reliant upon the pressing of a button in the Strava app or on their dedicated GPS device. Conducting the ride is the crucial first step into creating such artefacts. This, however, is only the first step in creating a ride. Once a ride has been created, users are able to curate their ride to reflect their experience; they can upload photos and videos taken while out on their ride. Such curation allows cyclists to express their corporeal experiences in a digital format, a logbook of their rides that enables them to relive the experience as often and as much as they like. Their experiences and bodily functions are transformed into binary representations that are quantifiable by the user (Lupton, 2017). The associated meanings applied to technologies are crucial to understanding how and why technology has become embedded within cycling practices (Schwanen, 2019). Where initial research like that of Barratt (2017) highlighted how self-quantification conducted through applications like Strava has helped increase their popularity, the following sections will explore the mechanisms that keep technology deeply embedded within the practice. It will also explore how these technologies influence the performance of a ride and the meanings imbued upon the digital and physical artefacts.

6.14.1 More than just a logbook

Cyclists are recruited into using Strava through word of mouth and brand recognition as discussed in section 6.11.1. During the interviews, there were strong themes of self-quantification present in their responses. This coincides with Millington's (2018) Fitness 2.0, in which users directly seek digitally displayed quantifiable feedback. Applications such as Strava reproduce rides in digital forms and present users with bodily and biometric feedback in a way that allows the user to explore an array of graphs, charts, leaderboards, and awards achieved on their rides. Strava also creates a catalogue or logbook of rides and activities that are neatly organised and navigated by drop-down menus. Notions of self-quantification were a leading motivation among the respondents. Strava allowed them to track and monitor data and compare their performances over time, either against themselves or friends (Lupton *et al.,* 2018). Using Strava as a form of logbook or cataloguing rides has become normalised through mass adoption and has become an essential part of cycling's socio-technical assemblages. During the interviews, reasons why the respondents joined and used Strava were talked about, as well as the use of Strava as a Logbook and/or catalogue of rides. James (25) was keen to state that before he started using Strava, he did not feel like his cycling was "missing much", but this has changed since he started using the application. James (25) said:

> "I think probably just because it's there and other people do it. Like I said, I wouldn't; now I do use it, I wouldn't have to cycle without it, but before, I don't suppose I was missing too much. I use it mainly just to be able to track what I'm doing and being able to see things, but it wouldn't, if it was never there in the first place, then, I don't think I would have like needed it so much. Like I said because before I was just using, I wasn't using anything, so I didn't know how far I'd been or how long I'd been out or that kind of stuff, and that was fine, but, ever since I was introduced to it, there's been no looking back really, and I use it all the time."

James's response highlights that before he started using Strava, he was not aware of the distances he travelled or how long he was out cycling for. However, since he started using the application, he could not envisage riding without it. His main use for Strava now is to keep track of his rides. He also admitted that he uses it "for tracking what I've done so I can log it, I can see myself how far I've been during the week". This is a feature built into Strava that tracks weekly distance totals for its athletes, providing them distance, time, and elevation totals. While James liked to see his cumulative weekly totals, Charlie, another cyclist, used Strava to catalogue his rides and more readily compare his own performances. Charlie (26) stated:

> "It's just nice to have a log; it's like a virtual logbook of everything you've done as well, so I quite like that aspect of it as well. So, well, while kind of short-term I like, I like using it to compare myself against me and see how I'm improving getting better, long-term it's nice to look back and see what you've done and actually think, 'yeah, I've had a pretty good year, I've got out loads' and sometimes you forget about those without having it logged down."

Charlie takes the self-surveillance of Strava further by using it to compare his performance against his past self. He later stated that it “gives you better insight into what you’re doing” by tracking his rides he can monitor his performances to improve his fitness levels. Not only does Charlie like to compare his past efforts he also enjoys using Strava to go back and relive previous rides. He stated that without logging his rides, he would forget all the rides he had been on. The ability to look back through a catalogue of past rides transforms Charlie’s experience from an ephemeral one into a lasting memory that he can reflect upon and relive. Strava, therefore, adds another element to the experience of cycling, transforming what once relied on inherent motivations (Chen and Pang, 2012) into a motivational tool to encourage technologically mediated routines and practices (Shove, Pantzar, and Watson, 2012; Lupton *et al.,* 2018). These two quotes emphasise that Strava is more than just a logbook, and its basic functionality has increased motivations that can affect the experience of cyclists. This suggests that by using Strava, cyclists’ motivations can be altered and transformed in positive ways that keep users engaged with the technology. This is supported by Neil (44), who finds Strava a “motivational tool”. He finds that by using Strava, he actively wants to see his improvements on similar routes; by using Strava and tracking his performance, he can quantify whether he is a “better rider” by making such comparisons. Neil (44) also said that he finds Strava holds him accountable to his peers on:

> “If you wasn’t recording people’ll think, and if you’ve been doing it and you haven’t, people’ll think you have been going out for ages ‘what’s the matter with you?’ and you know, just because you ay [have not] recorded or uploaded anything you know, you think, so it’s nice to have a little bit of, you know, nice for people to give you some kudos”.

Neil feels a level of accountability by uploading his rides to Strava due to the aspects of social surveillance (Lupton, 2017). The online sociability of Strava allows users like Neil to feel a sense of achievement by receiving affirmations through kudos and comments from his peers. This supports the notion that social integrations in online communities increase users’ motivations to perform exercise (Thiel, 2016) and provide a sense of community even when the performance is solitary (Rivers, 2020). This also furthers ideas that social and cultural experiences are also increasingly created through online social networks and that Strava is a platform that facilitates social interactions with other like-minded individuals. Brian (34) also admitted he felt an obligation to upload activities to Strava because of the social surveillance:

> “I think it, makes me feel more, accountable for my ride. Because there’s that social pressure being put on Strava. So, so, there’s that constant thought about trying to make the numbers look as good as possible.”

Just as users felt accountable due to the social surveillance experienced on Strava was the ability for users to set self-imposed targets. Users could set cumulative distance targets. These targets could be weekly, monthly, or yearly. This level of self-surveillance allowed users to track and visualise their cycling goals. Users like Krish (40) explained that they liked to set self-imposed targets to quantify their cycling:

> “When you put like ‘OK, I will ride 500 kilometres in a month’, and then when you see the first ones [rides] really didn’t do anything, you’re slacking off. Then I thought, ‘OK, maybe sometimes I have to catch up,’ so it actually keeps you motivated, it keeps you on target, and you kind of know where exactly you should be doing, or what exactly you should be doing, so yeah I think that keeps you motivated.”

Strava, therefore, is not just a means of tracking one’s ride. It is a tool that facilitates users' connecting and socialising with friends and strangers who are also in pursuit of improving their own fitness (Millington, 2018; Rivers, 2020). By using Strava, users have the ability to relive their past experiences and monitor how they have improved throughout the years. Some of Strava’s features highlighted above also feed into the motivations of cyclists - particularly those of goal setting. By setting goals within the application, users can monitor their progress and see how their activities enable them to come closer to achieving their goals. These feelings of accountability and motivation enable Strava to become embedded within the social practices of cycling (Shove, Pantzar, and Watson, 2012).

6.15 Strava: socialised gamification

Examining the interviewee's motivations for using Strava has helped articulate the effects Strava has on the temporal (co)production of space. Digitally mediated spatial interactions produce digital artefacts. These digital representations of cyclists' rides provide them with access to virtual online competitions, leaderboards, and trophies. Not only are users provided with an online competitive platform, but they also have access to a vast suite of tools that allow users to take part in extensive self-surveillance and self-quantification. Strava provides its users with the tools to analyse their rides in forensic detail, whether that be their biometric data gathered by a plethora of external sensors attached to their bodies and bikes or through detailed analysis of their performance on specific stretches of road. This level of functionality has resulted in Strava creating rides that are, as Rivers (2020: 1) states, both "gamified and biomedicalized". Strava's gamification features are not identifiable in physical space without access to the application; instead, they cast spaces in "layers of digital content" (Leszczynski, 2019: 16). These layers cast a network of 'digital shadows' or 'augmented realities' upon the world that are then represented as segments overlayed on a digital map in Strava. Such transformations of physical landscapes into digitally timed sections of road influence cyclists' experiences within the physical space. They experience it not just through their physical exertions but also with the knowledge of augmented reality. As Barratt (2017: 1) theorised, these digital shadows "augment the ride structuring and shaping connections which can be engaged with on and off the bike".

While users have already reported that Strava increased their motivations and made them feel accountable, gamification can further increase motivations. In this regard, Strava is able to provide users with new meanings to ascribe to their cycling practices and further solidify its place as part of their cycling socio-technical assemblage. Meanings that are associated with Strava are continually (co)produced and cultivated with each (re)enactment. The emotional and symbolic significances experienced by cyclists are applied to their practices but remain invisible before, during, and after each ride. However, the responses during the interviews highlighted how the gamified nature of Strava had added new layers and complexities to their rides that affected their performances both physically and mentally. Through exploring the suite of tools Strava provides cyclists, the complexity of these socio-technical assemblages becomes more apparent. Although Strava has a multiplicity of meanings to the cycling community, it remains a single entity, “a single object over which we may have different perspectives” (Law, 2002: 33). In this regard, the influence of Strava is experienced both individually and collectively. Individual cyclists experience and use Strava according to their specific needs of self-surveillance and self-quantification, participating in segments and leaderboards as they wish. However, Strava is broadly a single athletic social network providing users with a unified digital social experience.

Strava is an inherently social experience. Users are encouraged to interact with each other’s activities, which are displayed in a feed or timeline. They can see how far a person has travelled, the elevation gained, the time taken, a map of where their route went, and their virtual medals or trophies (if they achieved any). Users are also able to name their rides, provide descriptions, and upload photos. These descriptions can act as a diary entry and help to elicit richer memories within the users. Eva (59) recalls:

> “I guess it’s just giving it a story, and then, I guess, that also from me personally. I quite enjoy that little challenge about what I’m going to call that today or what am I going to write about today. It’s a bit like writing a diary, but also it helps me remember that ‘oh yeah, that was the ride that such and such fell off’ or whatever. […] It might be the weather, it might be how I’m feeling, it might be something that happened, it might be a view. And I guess that adds an extra dimension that we’ve not mentioned is that kind of reflective side to it that before I started doing this, I didn’t particularly do so much, and that’s almost like not

> meditation, but I've forgotten the words now, like mindfulness slightly" (Eva, 59).

Naming rides is something that Eva finds therapeutic and enhances her experience. She also reported that she was more likely to interact with a ride that had been given an interesting title and description. Aspects like being able to rename rides and personalise them increases the sociability of Strava. Strava's primary function is to replicate the sociability of club and group rides virtually (Strava, 2022a). While much of Strava's gamification relies on extrinsic motivators that reward users with medals and positions on a leaderboard, the social networking aspects of Strava have been shown to increase participation in gamification and increase the intrinsic motivations of users (Thiel, 2016). Just like Barratt (2017) found, these social aspects were largely positive with the interviewees, with cyclists interacting with each other through the kudos or commenting functionality. Personalisation of rides and online social aspects "mediates forms of mutual recognition with others-at-a-distance" (Michaels, 2009: 87). This combination of social and reward-based gamification provides an experience that can be enjoyed by a majority.

Strava's scripts are inherently gendered. The segments feature relies on competitive scripts based around "masculinity, mastery, and speed" (Barrie, Waitt, and Brennan-Horley, 2019), for some these traits can provide extra motivations for their rides. However, sporting masculinity and extrinsic motivators can potentially alienate some users (Thiel, 2016). While Barratt (2017) posed Strava may encourage or increase gender inequalities in exercise, this has been backed up by Barrie, Waitt, and Brennan-Horley (2019), who found female cyclists were subjected to sexualised surveillance as peers could track and see where or what groups female cyclists ride with. This sexualised surveillance can lead to ethical implications for female cyclists using Strava. The publication of rides on Strava can lead to unsolicited communication for female cyclists, as Olivia (37) experienced:

> "I was up training at one of our military places because there was race coming up but it's public, it's private land, but the public can go on it,

> and then some guy started messaging me saying, or commenting on it saying if you were, 'I saw you out riding' or something like that 'if you want to if you want me to show you around the area then let me know' I thought well that's kind of nice, but it's also kind of creepy at the same time" (Olivia, 37).

Olivia experienced unsolicited contact from what she referred to as a "Strava Stalker". Olivia's Strava stalker had seen her out on a training ride and used a function of Strava called Fly-by (users can view rides or activities of other people they have passed while out training). Initially, Olivia saw this as a kind gesture but soon realised that it added an additional element of risk to her self-surveillance practices. Olivia had already been acutely aware of the inherent risk of tracking rides due to her employment in the military, where she had been briefed on ensuring her activities did not follow predictable routines. This heightened her awareness of gender inequalities with self-surveillance applications like Strava. Eva (59), on the other hand, used the technology to inform her of a safe place to run in an otherwise unfamiliar area. She remembers:

> "I was in an unfamiliar place this year, and I had the chance to go for a run, and I didn't really know where to go, and without some way of looking about where runners were, I probably wouldn't have gone because I wouldn't have felt comfortable. And so, I had a look at the segments in the area and saw where runners went to run and deliberately went somewhere where I wasn't too far away from where we were staying but where I felt comfortable running" (Eva, 59).

Strava provided Eva with information of a popular running route in this new area. While male participants spoke of conducting their exercise abroad or on holidays and being able to fit in around familial commitments, this highlights an additional consideration by female respondents. Researching public and popular routes to feel "safe" in unfamiliar areas. Although this experience shows the benefits of technology, it highlights the gendered inequality faced by female athletes. Both these experiences further highlight how exercise remains gendered and that while technology can help reduce risks for users like Eva in public spaces, it can also produce unsolicited online attention through its social aspects and built-in features. Gender disparity within applications like Strava will also be discussed later in the thesis in section 7.5.

The online scripts of Strava provide users with extrinsic motivators like digital trophies and leaderboards to encourage them to participate in and compete against themselves, their peers, or even strangers. Trophies and badges achieved through these scripts are displayed on users' profiles (Figure 6.6). These profiles showcase their activities to their followers and themselves. Strava also provides users with an overview of their activity for the year and a bar chart showing the amount of activity (or inactivity) they have completed for the year. These graphical user interfaces can provide users with motivation to not skip training in order to achieve a consistent yearly total. It can also, as Barratt (2017) found, provide users with insight as to how serious of a cyclist users are by examining the overviews available on their profiles. The screenshot in Figure 6.3 below shows the author's Strava profile page. These profiles can act as a motivator in themselves, driving cyclists to have a compulsion to ride and record, which will be discussed later in the thesis. The image below highlights some of Strava's inherent gamified features that are not too dissimilar from those found in computer games (Barratt, 2017). From Figure 6.3, it can clearly be seen how active a user is in the presence of the digital bar graph. Strava also provides an overview of their activity within the last four weeks, along with a digital avatar, an overview of pictures added to uploaded activities, statistics (social and based on activity), and an overview of the trophies users have achieved.

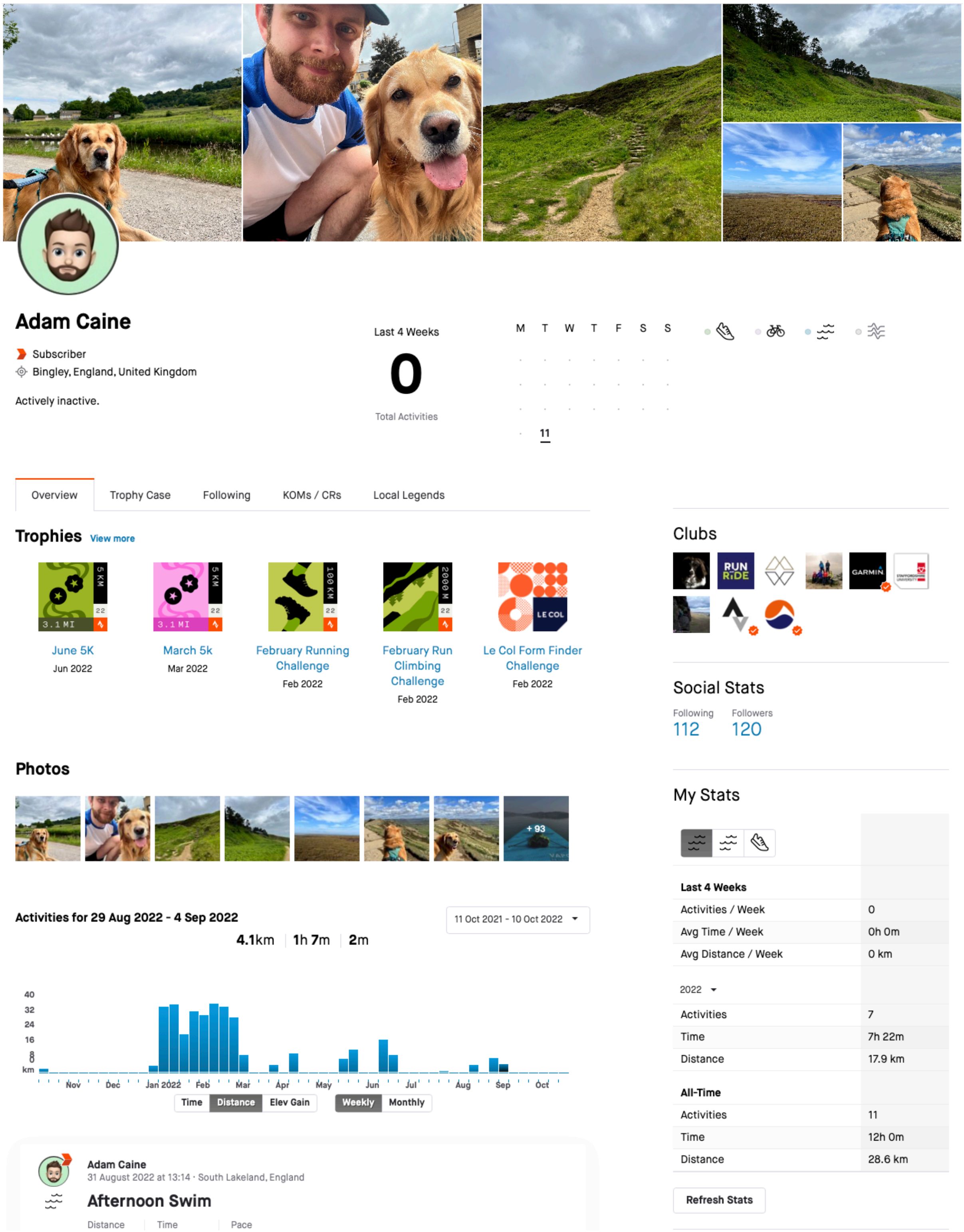


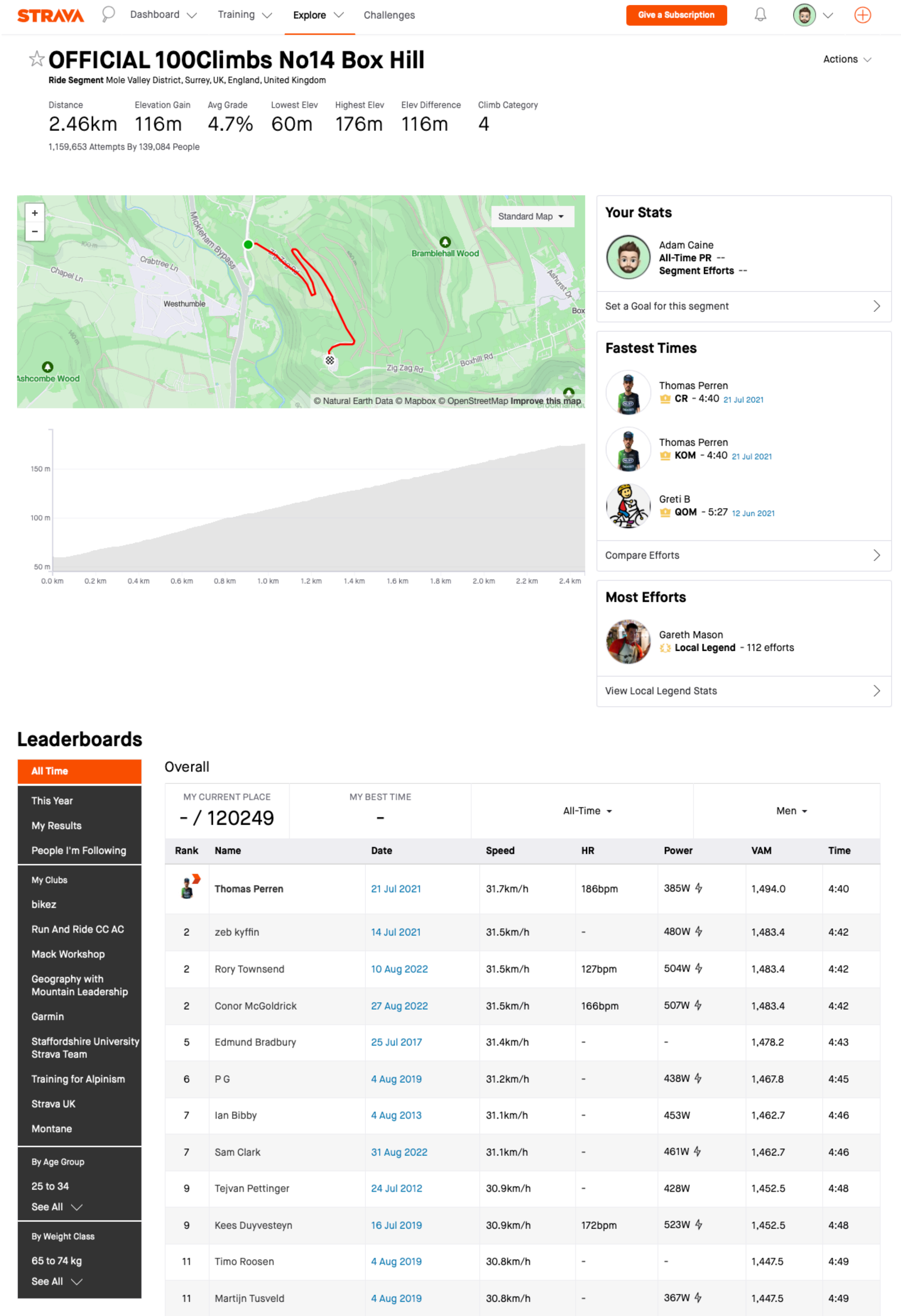
Figure 6.4 Authors Strava profile highlighting levels of inactivity.

Strava shares much of the hallmarks of gamification that Sailer *et al.* (2013) found. Some aspects of Strava's scripts directly affect the extrinsic motivations of its users through a series of leaderboards, challenges, and rewards. It is through practice theory that this research elucidates on this technology's role within cycling and how, through each (re)enactment, the cyclists-device-Strava assemblages (co)evolve and (co)produce their performances and experiences of space (Hand, Shove, and Southerton, 2007). Building upon Barratt's (2017) initial research into the gamification of cycling by exploring accounts of users' experiences with Strava, this empirical review aims to further explain the unique role Strava's scripts play as an integral part of cycling's socio-technical practices and how they have become entangled within their cycling routines. The following sections draw upon the interviews to further understand the complexities of Strava's scripts and their influence upon cycling practices. It will examine how cyclists interact with the various aspects of Strava's online gamification and performative evaluation tools.

6.15.1 Segmented experiences

Strava segments are an important aspect of its gamification of cycling and active leisure. Before this section considers the effect segments have upon cycling practices, it is important to understand the mechanisms of segments and how they are generated and assigned to rides. Segments are specific sections of the route, such as a climb, descent, or interesting stretch of road or trail. Segments are user-generated, meaning anyone who uploads a ride can designate a portion of that ride as a segment. Once a ride is uploaded, it is matched against Strava's database of these segments, and the user can explore the segments they have ridden. Cyclists can compare themselves against their previous efforts on a particular segment and compete against their friends and even strangers. Each segment contains an overall leaderboard that awards the fastest cyclist, a King or Queen of the Mountains (KOM/QOM), for completing that segment in the shortest time. KOM/QOM are awarded to the 'All Time' leader on the leaderboard but are not the only awards cyclists can receive. Those who place within the top ten cyclists are given a trophy for ranking amongst the ten fastest cyclists. There are also personal awards given to cyclists who achieve their own personal fastest, second fastest, and third fastest time, respectively. More recently, Strava has introduced a Local Legend award, which recognises the cyclist who has ridden a specific segment more than any other athlete in a rolling 90-day period of time.

Segments augment physical environments and reproduce them as a digitally mediated competitive space. These reproductions of space can create highly contested digital leaderboards of desirable hill climbs, descents, or trails. Segments are explorable by users and can, in some instances, influence their route choice to incorporate them within their rides. While segments can be created purely for user interest, some are digital representations of popular climbs, particularly the Top 100 Climbs (Figure 6.7), which was authored by Simon Warren (2010). This is a guidebook that takes the user through 100 climbs in the UK that are of significant interest or are a challenging climb to attempt. The transposition of Warren’s climbs into digital segments validates these augmented realities and can become coveted more than rider-created segments. This has resulted in the top 100 climbs becoming popular segments within UK cycling culture and receiving many ascents a year. For instance, Box Hill (Figure 6.3) – one of Simon Warren’s Top 100 Climbs - named Strava’s most popular segment in 2019 (Smith and Elton-Walters, 2019) has received, at the time of writing, over 20,000 ascents for 2022. Although books like Warren’s provide segments with validation they are largely (co)produced through practitioners interacting with their digital artefacts post-ride. This can, in some cases, lead to highly gendered segment experiences whereby users can create and name their segments with little to no intervention (although they have removed racially offensive segment names. See Welch, 2020). With segments, the cyclist is entered into a digitally mediated competition, whether against themselves, friends, or strangers.



STRAVA Dashboard Training Explore Challenges Give a Subscription

OFFICIAL 100Climbs No14 Box Hill

Ride Segment Mole Valley District, Surrey, UK, England, United Kingdom

Actions

Distance	Elevation Gain	Avg Grade	Lowest Elev	Highest Elev	Elev Difference	Climb Category
2.46km	116m	4.7%	60m	176m	116m	4

1,159,653 Attempts By 139,084 People

Your Stats

Adam Caine
All-Time PR --
Segment Efforts --

Set a Goal for this segment

Fastest Times

Thomas Perren
CR - 4:40 21 Jul 2021

Thomas Perren
KOM - 4:40 21 Jul 2021

Greti B
QOM - 5:27 12 Jun 2021

Compare Efforts

Most Efforts

Gareth Mason
Local Legend - 112 efforts

View Local Legend Stats

Leaderboards

All Time
This Year
My Results
People I'm Following
My Clubs
bikez
Run And Ride CC AC
Mack Workshop
Geography with Mountain Leadership
Garmin
Staffordshire University Strava Team
Training for Alpinism
Strava UK
Montane
By Age Group
25 to 34
See All
By Weight Class
65 to 74 kg
See All

Overall

MY CURRENT PLACE - / 120249 | MY BEST TIME - | All-Time | Men

Rank	Name	Date	Speed	HR	Power	VAM	Time
	Thomas Perren	21 Jul 2021	31.7km/h	186bpm	385W	1,494.0	4:40
2	zeb kyffin	14 Jul 2021	31.5km/h	-	480W	1,483.4	4:42
2	Rory Townsend	10 Aug 2022	31.5km/h	127bpm	504W	1,483.4	4:42
2	Conor McGoldrick	27 Aug 2022	31.5km/h	166bpm	507W	1,483.4	4:42
5	Edmund Bradbury	25 Jul 2017	31.4km/h	-	-	1,478.2	4:43
6	P G	4 Aug 2019	31.2km/h	-	438W	1,467.8	4:45
7	Ian Bibby	4 Aug 2013	31.1km/h	-	453W	1,462.7	4:46
7	Sam Clark	31 Aug 2022	31.1km/h	-	461W	1,462.7	4:46
9	Tejvan Pettinger	24 Jul 2012	30.9km/h	-	428W	1,452.5	4:48
9	Kees Duyvesteyn	16 Jul 2019	30.9km/h	172bpm	523W	1,452.5	4:48
11	Timo Roosen	4 Aug 2019	30.8km/h	-	-	1,447.5	4:49
11	Martijn Tusveld	4 Aug 2019	30.8km/h	-	367W	1,447.5	4:49

Figure 6.5 Screenshot of Box Hill Official Top 100 climbs segment page on Strava

During the course of the interviews, Strava made a significant change to the segment feature. Since Strava was released in 2009, segments had been freely available to all members; however, in 2020, Strava moved the functionality of segments into its Paid Premium membership (Stuart, 2020). This has been reflected within some of the responses, as members who were on Strava's free membership expressed their frustrations at what is considered to be a fundamental part of the Strava experience. Users' times are still entered into the segment leaderboards and can receive their fastest times but do not have the ability to use the segment analysis features (Figure 6.8) or view their previous times. Strava cited a reason for this change as segments being a large part of their overall operating cost, and as a "small they were "still not profitable" (Stuart, 2020: n.p). The decision to include this within the thesis is due to it being a significant change to Strava's business model. As a significant portion of the interviews occurred before this change came into effect there can be no significant conclusions drawn as to whether this had an impact on users' decisions to upgrade to Strava Premium memberships.

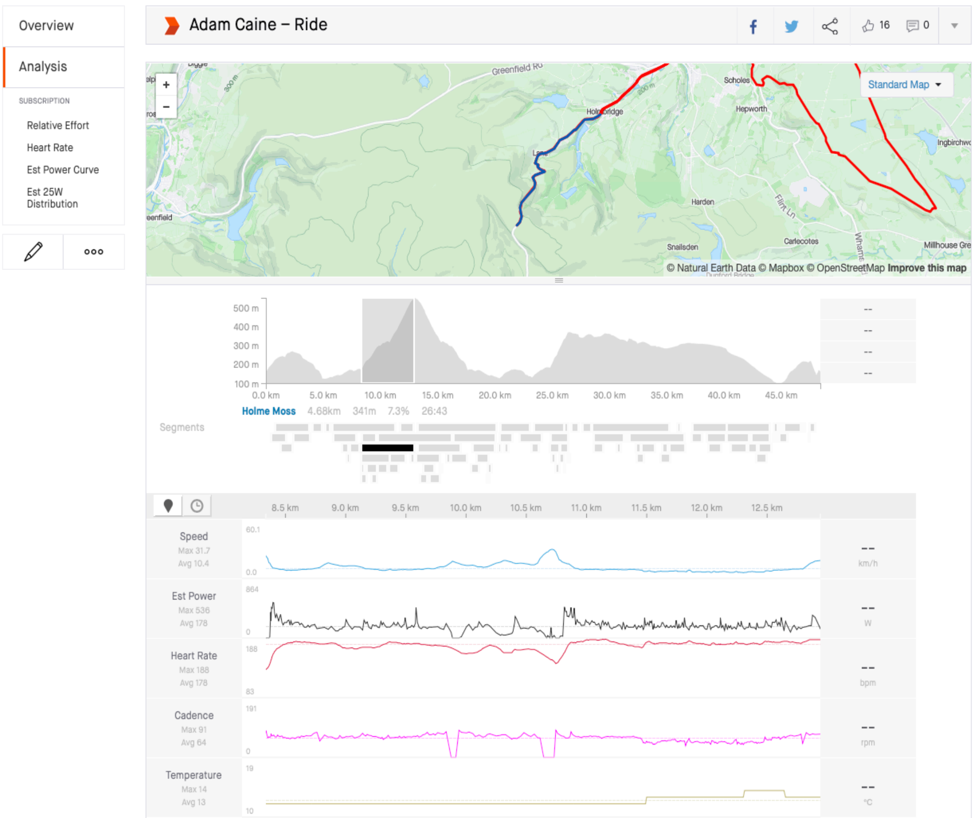


Figure 6.6 Screenshot showing the analysis feature removed from the free version of Strava now only available to premium members.

Segments have become a part of cycling practices casting their digital shadows over physical spaces. These hybridised spaces further blur the physical and digital spaces that cyclists traverse with the enactment of their technologically mediated rides (Leszczynski, 2019). Such spaces were once distinctly separate but have now become enmeshed through the (co)production of space during their rides. In 2015, Strava introduced the live segments feature, which allowed users to classify segments as 'favourites' and sync them with compatible Garmin Bike Computers (this feature was later introduced to other devices and the smartphone app). This feature alerted users when they were at the start of a specific segment and provided them with the ability to pace themselves either against their own personal record or against the KOM/QOM. Strava live segments allow users to become more openly competitive within the physical environment, as Olivia (37) explains:

> "Yeah, so, I do quite like the[m], and that was one of the things about the Garmin, the actual segments, the live segments. I quite like that feature, so initially, I was using it as a bit of a training side of things, and it has become competitive with, like, especially your mates or people that you know as well like other local people. We've got a few little, like, local mates who are all chasing the same bits or trying to dominate a certain area, so yeah, I do find that pretty motivating, and yeah, quite good fun."

Segments themselves can take on different roles for each individual user; in this case, Olivia explained that her use of segments had changed over time - the more she had used them, the more competitive she started to become. Initially, she had used them as an aid to interval workouts where she sought segments that would last for the same length of time as the interval: "I have used it [segments] where I've found segments are of the right interval". Narratives like this show how these digital practices are fluid and (co)evolve as the practitioner becomes more familiar with the scripts and experiences digital creep. As mentioned earlier, users can compare their previous efforts on the segment page, a feature that Olivia found particularly useful within her training. Olivia (37) explains:

> "I've used that [segments] to then monitor, and I can go back to it, and I can have a look at the Strava and things; 'well, I was really good on the first one, really good on the last one, and then I just sort of did steady ones in between' or I crashed and burnt at rep number four, so yeah, I've used the segment feature quite a lot for that" (Olivia, 37).

Olivia's training was digitally mediated through the use of segments. This further solidifies the notions of hybrid spaces and augmented realities explored in section 4.4. Segments also played another role within her cycling practices by allowing her to compete against her friends and local cyclists on these segments. Many of the respondents also had shared experiences using segments to add an element of competition to their rides. Leo (19) explained that when he was not doing a specific training ride, he would actively compete on known segments: "If I'm doing a ride, a free ride here, I'm feeling good and stuff, I do like trying to take segments on stuff where I know there is one". By 'taking' a segment Leo is referring to the leaderboards and competing for the coveted King of the Mountain title.

Strava further encourages competition on its leaderboards by notifying cyclists when they lose their top spot. The competitiveness of segments changes the meaning of the ride. Particularly in the case when cyclists lose their top position, which enables feelings of a compulsion or desire to go out and reclaim their title as King or Queen of the Mountain. Both Sophia (40) and Olivia (37) revealed they had received email notifications alerting them to having their place taken from them. The email affected Sophia's motivations for her ride, whereby she felt an increased urge to go and take it back: "You get notifications if someone takes your Queen of the Mountain, so you wanna get back out and take it back on that particular segment." This is mirrored by Olivia's response where she considered Strava segments had encouraged her to ride more competitively:

> “I think it’s actually made just normal riding a little bit more interesting as well, so even a little blast around the local heath with mates you can, then every so often we have like a little competition, or, if someone's, you get the email ‘Uh oh! You’ve stolen your Queen of the Mountain’ right, well next time I go out ‘round there, I’m gonna give that a bit of a go, so I think it’s added a bit more competitiveness to normal riding, almost a bit like virtual racing.” (Olivia, 37).

The use of segments has changed cyclists' experience of cycling. 27 out of 38 respondents felt that this was a positive change and that the use of Strava had added an additional element to riding their bikes. Like Olivia states above, Strava and the segment feature adds an extra element of competition to her rides and compares it to “virtual racing”. Interviewees used the segment features post-ride to review their performances and see how they have improved upon themselves or where they rank within the Leaderboards. This is further confirmed by Jacob (22), who looks over his segments and awards during his post-ride review, where he “look[s] at the segments how close was I to getting the KOM”. The descriptions from respondents indicated that their spatial experiences are (co)produced with segments. As cyclists actively try to reclaim their KOM/QOM Strava and the digital technologies, in that moment, represent how the knowledge of segments, and the applications scripts are internalised. These digital imperatives further show how the scripts produced by Strava augment the temporal practices of cyclists.

Despite King and Queen of the Mountains being an emotive topic for some of the respondents, not all of them felt that they could be actively competitive within the Leaderboards. Strava’s popularity is in part responsible for this, during its infancy users were able to experience healthy competition. The popularity of cycling and Strava has led to many of the segments becoming uncompetitive, save for elite riders, risk takers, or those with favourable weather conditions. This did not, however, mean that they avoided using segments altogether. Instead, narratives of digital creep highlighted that their motivations towards segments changed. Instead of adding an element of virtual racing to their rides, it gave them the ability to quantify their performances in more granular detail on specific sections of road. Cyclists are rewarded in various ways through the segment feature; as mentioned earlier in the section, cyclists can receive personal medals for improving their own times. When completing a ride participants like James (25) reported how they felt frustrated when they had not received any medals or achievements during their ride. James (25) stated:

> "I always try and beat my own times on segments all the time, but it's just not as easy as you think it is. Yeah, every time I go out, I think because I like seeing all the little medals as well next to your route when you post it on Strava, and it annoys me when I get back and I've got like one or none. I like to think every time I go out, I'm going to beat my personal best, but obviously that doesn't always happen."

While respondents spoke of their self-competitive experiences of segments being personal, users are still acting in accordance with Strava's gamified scripts. Instead of competing against strangers these scripts have become (re)configured and imbued with meanings of self-quantification (Lupton, 2016a). As James (25) said, not every ride will result in a new personal record for him; however, this self-surveillance and self-competitiveness add another element to his rides. Using the personal record and self-comparison feature of segments was popular among the respondents; nearly all of them who used segments found that they enjoyed this aspect. Particularly from responses like James's (25) segments, which have become embodied within his cycling practices and provided him with added motivations to try harder when he reaches certain points in his rides. This is also felt by Alex (43), who uses words like "challenge" and "compete" when referring to his own times on segments. For Alex, segments can be quite a "personal thing" on his rides, though, unlike James, he does not get frustrated when there are no personal records. Regardless of whether users compete for positions on segments or monitor their own improvements, segments (co)produce spatial and temporal interactions of cyclists. Segments have a profound influence on cyclists' spatial interactions, experiences, and their motivations. For those who actively compete for King or Queen of the Mountains they can influence their route choice to go and "take it back" (Sophia, 40) when they have lost their top spot.

Amongst the cyclists interviewed, their use of the segment feature was referred to as an added element to their cycling, and they spoke about it positively. Many felt that this had improved their cycling experience and provided them with some post-ride "banter" (Aaron, 53). However, segments can have a detrimental effect, particularly on social or club rides. As opposed to cyclists engaging in competition with those around them and "sprinting for a village sign" (Dansie, 2013: n.p), cyclists have become more preoccupied with forms of digital competition through Strava's scripts. Due to the increased use of segments within riding it has led some cyclists to compete for segments during social rides. For new cyclists and new club members, the use of technology in this way can be intimidating, particularly if they are not aware of the technology or how it is used. Discussion about Strava and GPS devices can become frustrating to those who are uninitiated into these practices. Robert (63) felt this when he joined his local club as a new cyclist. He tried to absorb as much information as possible in an attempt to become a better cyclist. However, during club rides, he remembered on a particular stretch of road, the other riders would "take off" to improve their times on Strava. Robert would be left behind as he could not keep up with the others. This was not an isolated incident either, as the club Sophia (40) rides with had to re-evaluate the meaning of a social ride:

> "Yeah, everyone uses technology in the club, and yeah, I think we went through a stage where some people were forgetting like what a social ride should be, and club social ride, and it was ending up being like a knockout contest for like how fast a club ride could be. So, as a club, we had to review that and make some changes, you know and remind people, yes, we had a big kind of consultation over that, so that's really off-putting for like new members, you know cause we say you know you should ride to the slowest member of the club but I think technology might have had something to do with that in terms of people become a

> bit selfish and forget that, kind of motto, that rule that you have where we support the slowest rider" (Sophia, 40).

Sophia explained that segments had a negative impact on the club's social rides and may be off-putting to newer cyclists, much like Robert had experienced when he joined a local cycling club, which made him feel frustrated. Sophia also emphasised that social rides need to cater to the slowest riders in the group, and the pace of their rides should reflect that as opposed to being used to better one's time on a segment, referring to them as "selfish". This practice was considered "anti-social" (Oliver, 46) and earned those who took part in it undesirable nicknames like "squirrels" and "willy-wavers" (Debbie, 44). Cyclists who are part of traditional cycling clubs felt that segments can have a negative impact on the overall experience of social rides despite how their own practices involve segments. However, for some groups of friends who cycle together (not as a formal club) segments can form part of a discussion where they intend on helping another friend to achieve a better time or create a race situation in which they can compare their efforts post-ride to see who achieved the best result.

From the interviews, segments are used in a myriad of ways by cyclists, and they form complex meanings within their practices. As explored earlier in this section live segments can be a motivator for cyclists to try harder on a particular stretch of road or aid in their specific interval training. A common theme amongst the respondents is that segments are a retrospective part of their practices whereby cyclists like to see improvements in their own times and receive digital medals to affirm their achievements. Strava's development of segments has created a platform from which cycling practices have (co)evolved. The primary function of segments is a means of gamifying and augmenting real-world experiences where users can compete informally against others at any time, however, from the interviews conducted this feature has taken on new meanings. Building on Latour (2000) practice theory shows how material elements (non-human things) can affect not only affect practices and are an integral part of the practice, but it is only through consistent (re)enactments (Shove and Pantzar, 2005) that segments have taken on new meanings. These new meanings have (re)configured (Reckwitz, 2002; Shove, Pantzar, and Watson, 2012) the practices of cyclists that reflect their personal motivations. Just as practices' survival are reliant on each (re)enactment they (co)evolve over time (Shove, Pantzar, and Watson 2012) Strava's segment feature has also received several updates to maintain its relevance. These updates ensure users maintain their interactions with the feature. As explored above, these (co)evolutions of Strava segments – personal records, annual leaderboards, live segments, and local legends – prevent the practice from dying.

6.15.2 Challenges: incentivised cycling

Another feature of Strava's gamification is called Challenges. Challenges are specifically designed to increase the motivation of its participants to complete a specified goal. By taking part in challenges, users receive regular progress updates in their feed when they reach milestones, such as completing 25% of a particular challenge. Once the challenge is completed, users receive a digital trophy stored in their digital trophy case on their profile (Figure 6.9); some challenges provide users with rewards, these are often sponsored by different companies. Rewards can range from entry into online competitions, money off items, or even sew-on patches that were once awarded for completing the coveted Rapha Festive 500 that runs yearly between Christmas and New Year's Eve. Challenges differ from user-created goals in that the goal is predefined by Strava and/or the sponsor. Challenges can be based upon cumulative distance, time, or elevation or require users to complete a specific distance in a singular activity (e.g. ride 100 kilometres). Challenges can also be active for varying lengths of time, from days or weeks to lasting an entire month. Accompanying the challenges are specific requirements that users must follow for their activities to count towards the challenge. Challenges transform geographic, physical experiences into digital information that works towards a specific goal. However, unlike segments, challenges are not digital representations of physical spaces, and as such, they do not augment the cycling experience in the same way. Some of the interviewees regularly took part in the challenges on Strava and spoke about how motivating they found them to be. For Emily (28), the challenge feature was particularly motivating for her:

> "Things like the Festive 500 I've done a few times; I remember when I was first riding, there was some challenge; it was like ride 200 miles in two weeks or something like that, and I was so excited about it, and I had like, a little spreadsheet of how I was going to do it commuting to work and back every day. And yeah, I found that really, really motivating, there's some that happened every week that's just like, every month that's like ride 100 K[ilometres]and that's just a bit boring."

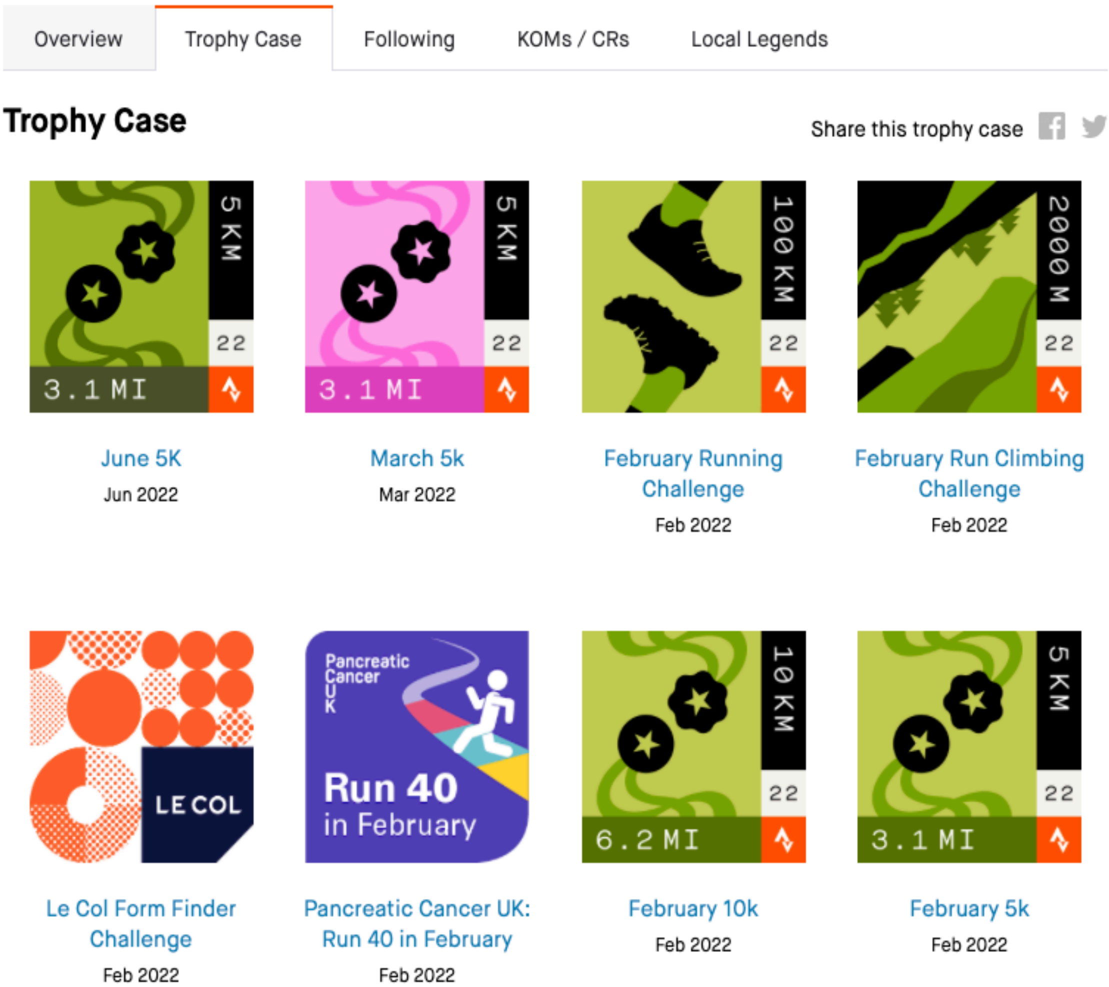


Figure 6.7 Digital trophy cabinet of completed Strava Challenges.

Emily's quote describes how her cycling was influenced by the challenges she took part in and how they were a motivating factor in encouraging her to actively ride more. The challenges also resulted in Emily planning out her riding so that she could complete the challenge while still maintaining her regular work commute by bike. She produced a separate digital artefact to organise her riding schedule for the duration of the challenge. James (25) also spoke about how he enjoyed taking part in the monthly challenges, stating that he was “addicted” to them and found them to be motivating towards his riding. He found the challenges to encourage more competition within himself to complete the challenge on time. However, despite the increased motivations felt by James and Emily, for many of the respondents, the challenge feature was not a primary source of motivation, nor did they often speak about actively seeking out the challenges and working towards them with their rides. Instead, the challenges were something that they would join and let fade into the background of digital rides. Many of the respondents spoke about the challenges with apathy. This was the result of them either joining challenges and consistently not completing them or consistently completing within the realms of their normal cycling. Phil (35) used the challenge feature but did not actively take part in completing them:

> “Yeah, I take part in the challenges, but only because it’s there and I just click on it. I don’t really take it seriously it’s just a, I think there’s a distance challenge that I don’t usually tend to hit at all cause I think its 1250 kilometres every month and I tend to be about a 1000 or so. It doesn’t really motivate me to hit that as well; it’s just something that I click on at the beginning of every month. It’s easier then to see quickly on Strava you know, for where you are in the month.”

Phil’s experiences are reflective of many of the participants; challenges are not actively sought after and are often joined out of routine and just because it “pops up your mates joined this I’ll do it” (Olivia, 37) or because they are “bored and just want something to look at and do” (Jacob, 22). Unlike other aspects of Strava, the challenge feature does not have the same impact on cyclists’ motivations. For Phil, the challenges are used as a feature to quickly quantify how much cycling he has done for the month; his actual motivations remain unaffected as he stated he consistently does not complete the challenge. In contrast to Phil's experiences, Greg (57) consistently completed the challenges:

> "I used to regularly do the distance and vertical challenges every month until about 18 months ago. I thought, well, I'm, I'm, I'm completing them all religiously without even thinking about it, so there's no point in cluttering up my activity timeline with, challenges."

Greg no longer found the challenge feature *challenging, and as a result,* he stopped taking part in them. He also referred to them as "cluttering up" his activity feed; this is due to the feedback users receive for completing challenges being visible in the main activity feed. Challenges are utilised differently to segments. Segments are a form of active competition between others or themselves, whereas challenges are predominantly seen by cyclists as an afterthought. Challenges are not reliant on physical landscapes for their existence, and despite users being rewarded with digital trophies of their achievements they remain an insignificant part of many cyclists digital cycling practices. Although they are designed to help increase intrinsic motivations, they had little real-world effects on their cycling practices. Though challenges bear hallmarks of self-quantification, tracking distance, time, and elevation (Lupton, 2016a), they were not imbued with the same meanings that had been applied to segments and, as a result, were not as successful in propagating into cyclists' embodied practices (Shove, Pantzar, and Watson; 2012).

6.15.3 Training and performative review

During the course of the interviews, it was apparent that training was, for some, an important part of their cycling practices. Training features were particularly important for respondents who worked with a coach that provided them with specific training plans;, however, not all of those who used the training features had a coach. Strava offers a number of features that are focused on informing cyclists' training. Strava offers a 'training calendar' feature that is available in the free version of Strava. The training calendar provides users with an overview of the year and a cumulative summary of all their statistics: total time, total distance, total number of personal records, and total number of activities. For those that pay for a subscription to Strava (either monthly or yearly) they have access to a more in-depth suite of training tools; these are: training log, training plans, power curve, fitness and freshness, and relative effort (previously referred to as suffer score). First, the training log is a more detailed visual overview that allows users to see their progress and important statistics. Information is broken down by week, and activities are shown as circles on the day it occurred and are colour-coded depending on the type of activity recorded. Users can filter their information by type of activity and can alter their weekly cumulative summary by either time, distance, elevation, or relative effort.

For those that use the training log, it provided them with an overview of their current training activities. For Jacob (22), the training log, coupled with the power curve data, allowed him to see his current fitness trends and how his training was going. Whereas for Olivia (37), the training log was initially used in conjunction with a coach:

> "So, I use it to initially to go back and provide my coach with feedback so it's an easy way of looking at the data now I sort of use it to go back and like identify good rides. So, I can sort of roughly remember when it was, and if I do put a little description about it so it's not just 'morning ride,' I can go back and think, 'Ah, that was a good ride let's go and do that route again'. So, more use it for route planning a little bit now, and now I haven't really got a training program. It's a case of just keeping yourself fit while until, like, any sort of racing happens again."

Olivia would previously provide her coach with information from the training log so he could "see things a bit more clearly" (Olivia, 37) rather than filling out a feedback form for each training session she completed. At the time of the interview, racing had been suspended due to the COVID-19 pandemic, and Olivia no longer had a coach. Her use of the training log had changed; she was now using it as an aid to remember rides that she had previously enjoyed and as motivation to go out and complete them again. Olivia's response shows how her real-world cycling is influenced by the use of the training log feature. Colour-coded activities, distances, descriptions, and even photos allow cyclists like Olivia to relive their past experiences and influence them to attempt to recreate those feelings once more by (re)enacting the ride. Olivia further justified the use of the training log features by comparing Strava’s subscription price to that of “two posh coffees” or “one posh Starbucks coffee” per month and that the value she receives from using this subscription is small in comparison to “what I get out of it”. Similarly, Chloe (28) was a Strava user who had recently purchased a subscription and was utilising these new features. Chloe also used the training log and was getting acquainted with the other premium training features available:

> “The training log looks really clear now, and they’ve got different colours for each activity. I’ve started looking at that quite a bit because it’s better than just the big graph that you’ve done this many kilometres a week. It’s nice to know now I’m doing running, and cycling, and pilates, and climbing it’s good to see the differences, and walking. And, I’ve recently had a subscription, so I’m using their relative effort calculator addition, which is quite interesting because it’s saying below average, and you think, ‘Oh, I'd better do a few rides this week, so I maintain my level of effort’” (Chloe, 28).

Unlike Olivia, Chloe did not take part in racing, nor did she use a coach to receive training plans. Chloe’s use of the training log provided her with greater insight into the activities that she takes part in. Along with this, it allowed her to differentiate how each of these activities was affecting and contributing to her overall fitness. Chloe also mentioned that the relative effort feature could increase her motivations to complete another ride to maintain her weekly average. Relative effort is a metric that is found on the activity details page and provides users with a numeric score to reflect how much cardiovascular effort has been put into an activity based on their recorded heart rate data. The purpose of this information is to provide users with the ability to compare their expended efforts across multiple activities. The weekly effort that Chloe referred to is the cumulative relative effort for the week; its purpose is to allow users to consider their training load to prevent them from overtraining, which can lead to injury or illness. In Chloe's case, she referred to her weekly effort as being below average, which means that compared to her normal cumulative weekly efforts, she had completed a lower-than-normal number of activities. For Chloe, this feature incentivised her motivations to maintain a certain level of effort, rather than the inherent want to go out and complete a ride Chloe's impetus had been provided by the technology itself.

Relative effort was previously known as suffer score, and with the score, users were given an adjective to describe their ride. This could be used as an affirmation by cyclists to quantify their performance. As Olivia (37) said, it "was one of those reinforcing things that are like bloody hell that was hard, and then when Strava says that it was hard, you think actually yeah, that's pretty cool". For Craig (25), however, the suffer score had some detrimental effects that meant he did not properly recover after his activities:

> "Strava used to have a function which was called your 'suffer score', and you know it was probably a bit gung-ho of you to really want a high suffer score, so you know I would work towards that. I would kind of like think to myself 'cor, wouldn't it be great for everyone to see that I've really slashed up this ride?' So, it got to the point where I was not resting as much as I could or I should you know, I'd be going out, at my peak, I'd be going out probably; I remember I did a 100 k[ilometre] ride once which was probably at my limit at the time making a good 29/30 kilometre an hour average speed. Definitely absolutely ruined me but I'd still go out for a 30 mile ride the next day as a inverted commas "recovery ride". But it wouldn't be a recovery ride because I'd want to smash it. I'd wanna see those numbers on that screen."

Craig had experienced a negative impact towards his cycling and overall health due to the relative effort feature. This quote expresses how this feature had shaped Craig's cycling and changed his physical exertion on his rides. Due to the sociability of Strava's platform allowing his peers to view the score he achieved on his ride, Craig felt that he wanted to achieve high scores so others could see just how hard he was working. When Olivia achieved a high score on a particular ride, she felt a sense of “pride” (Olivia, 37). Craig used it as motivation to ride as hard as he could instead of resting. Despite the feature being intended to aid users in managing their training loads, this had a contrary effect on Craig. This example shows that technology is reliant upon the users’ interpretations and the meanings that they associate with it. In Craig’s case, the technology served as a way of digitally bragging and showing off how physically demanding his rides were to his peers.

Fitness and freshness builds on the relative effort feature as a means for cyclists to understand the cumulative effect of their training. This provides another numerical metric for users to view, as well as charting their trends over time. Users can view how their fitness has changed over the course of three months, six months, the last year, the last two years, and all time. In a support article, Strava states that “the overall numbers aren’t as important as general trends” (Meg, 2022c). This means that while the feature provides a cumulative number based on the level of training a user has completed, the actual graph is more important as if the line trends upwards, a person is getting fitter, and as it trends downwards, they are losing fitness. For the respondents that used this feature, it did not form a significant part of their training. For Jacob (22), it was consumed as part of his post-ride analysis, where he would look at how many Fitness points he had gained: “I gained four fitness [points] today”. Olivia (37) and Sophia (40) used it more as a means to confirm how they were feeling after a particularly busy training period, whereby they should consider easing off or taking a rest day altogether. Olivia (37) stated: “maybe, sort of, realised that actually I, sort of, probably could do with a rest day”. The ability to see the overall trend meant that Olivia could factor in some rest to avoid over-training. This was mirrored in Sophia’s response, where she said:

> “Psychologically, if you’re feeling a bit like ‘ugh’ and you look at your data and you’re like, well yeah, you’ve probably been overdoing it, this is why you’re feeling a bit ‘ugh’, so go easy on yourself” (Sophia, 40).

Sophia's response showed that the fitness and freshness feature could confirm how they were feeling. For both Olivia and Sophia, the feature influenced their practices and informed their decisions on how much riding they should do and when or whether they should take a rest day. Much like how Chloe's (28) cycling was influenced by her weekly relative effort, the fitness and freshness feature coupled with how they felt in themselves allowed them to change their training and factor in either easier rides or even take a rest day.

Some of the respondents worked with specific coaches who developed customised training plans that worked towards enabling them to reach their specified goals. For those that do not have a coach and are an active Strava Subscriber, they have access to online training plans. These plans are developed with coaches from Carmichael Training Systems (CTS) and are developed to help cyclists achieve the ability to complete a 'sixty-minute climb', 'ninety-second sprint', or even 'beginner' and 'intermediate indoor training plans'. Despite this feature being offered, none of the respondents took part in these online training plans through Strava, though some of them stated that they may consider doing so. Liam (24) was one respondent who said he would consider using a training plan but that he "probably wouldn't follow them strictly" instead Liam would use the training plan as inspiration to conduct his own training. His reasoning for this was:

> "I sort of feel like I've got a good, sort of, understanding of what works for me and stuff, so I know which, with like training plans what suits one person doesn't always necessarily always suit someone else, and I know they probably are quite personalised because they can use your heart rate and stuff but yeah I like, I sort of, feel I understand myself well enough to plan my own training if that makes sense?" (Liam, 24).

Liam felt that he understood how his body responded to training more than an online training plan would be able to account for. Interviewees that had considered some type of structured training plan had not actively sought one provided through Strava, and those that had taken part in competitive racing, like Olivia, had plans developed to her personal needs by a coach. Strava's training plans received mixed responses, with no respondents actively enrolled in one. Many of the respondents stated they had been interested or perhaps would consider one in the future. However, there were two interviewees whose responses stood out as they were diametrically opposed to the idea of a training plan. Ryan (51) said, "I just wanna ride, and today I wanna ride far, so no, no, I wouldn't sign up for anything like that." Ryan had previously raced and stated that even when he raced, he never took part in any sort of training plan and said "Eddy Merkcx" in reference to a quote attributed to the late professional cyclist with regards to training Eddy Merkcx said: *"Ride as much or as little, or as long or as short as you feel. But ride."* Max (52) also did not conform to the idea of training plans as he was "absolutely allergic" to them. Max also felt that he understood his body better than a training plan could. Max and Liam both felt that their own instincts could inform their training to better suit their riding. While Liam had considered using training plans to inform and develop his own training, Max preferred to structure his own training around long low low-intensity riding that suited the type of long-distance events he took part in.

6.16 Digitising the body and practice

The acquisition of dedicated GPS devices allows users to explore more information about their bodies both on and off the bikes. Section 6.11.3 outlined why users upgraded to dedicated GPS devices due to issues with tracking via their smartphones. However, for many respondents, the ability to unlock more data through a series of connected sensors was another added benefit that encouraged them to upgrade to dedicated GPS devices. The previous sections demonstrated that features of Strava intended for pre-, and post-ride consumption can directly affect the embodied experiences of a cyclist's ride even though they remain mostly absent from the performance itself. The following sections explore how the cyclist becomes, through a host of connected sensors, a digitally-connected assemblage of technology. The historical development of biometric feedback has been covered previously (see section 3.3), and while some of the developments have been around for a number of decades, their use has become much more widespread as the technology has become more widely available to the average consumer.

The interviews focused upon cyclists' relationships with their technology and how they used it within their cycling to further elucidate the impacts technology had upon their cycling experiences. It became apparent through the interviews that the impacts technology has had on the socio-technical developments of cycling have been varied, but they have had an impact nonetheless. Much of the information gained from respondents was consistent with Millington's (2018) Fitness 2.0, where cyclists are increasingly seeking instant feedback in the form of "digitised" bodily functions (Lupton, 2014a: 615). The interviews focused on three main sensors that provided users with biometric information: cadence, heart rate monitors, and power meters (sections 3.3.4 and 3.3.5). Biometric feedback empowers cyclists with greater insight into their immediate performances (Lupton, 2014a). Strava provides users with augmented reality through its gamification of cycling and biometric feedback, which provides users with another layer of digital augmentation through live statistics that show users "how far I can push it" (Debbie, 44).

6.17 Sensor(ed) interactions

Cycling assemblages incorporate several devices – each one providing the cyclist with real-time information and feedback – a flow of data that seamlessly feeds into a flow of practices. Over time, these technological assemblages have changed to incorporate new technologies and their associated socio-technical practices. The following paragraphs will consider how these biometric sensors are used and how users are further recruited into narratives of digital creep. As participants begin using new means of quantifying their cycling performances and become accustomed to the information and how it is to be interpreted, they seek out further means of quantification. The discussions of cadence, heart rate monitors, and power meters with cyclists provide evidence of the (co)production of and subsequent (co)evolution of practices (Shove, Pantzar, and Watson, 2012).

“It’s [a] fundamental thing, right? If you can measure it, you can manage it” (Krish, 40). This is a salient point made by Krish, particularly when considering the role biometric technologies play within the practices of cycling. Their fundamental purpose is to measure an output that can provide meaning to that performance. Cadence meters are a basic measure of cycling output; while their data does not directly relate to physiological occurrences within the body, they can inform the user about the efficiency of their cycling and perhaps encourage them to try harder:

> “Cadence, I think is quite useful sometimes as well, I never thought I would use it but it’s surprising how you can get lulls in your performance just cycling on the flat and you think ‘well, I’m hardly pedalling’ and then you just up your cadence and it’s quite good to keep that, to just observe it” (Bill, 61).

This quote from Bill shows how the cadence meter influences his performance on the bike at a particular moment in time. For many people, cadence meters were their first introduction into tracking and digitising their bodily performances. Bill “observe[s]” his cadence to ensure that he is pedalling effectively. This is a strategy employed by professional cyclists whereby keeping a higher cadence (90-100 rpm) utilises their cardiovascular system more efficiently and reduces the load output on their muscles (Friel, 2009; Yeager, 2021). However, despite the ability to affect the output of cyclists’ cadence was not used or monitored by many of the respondents. This had often been superseded by other bodily metrics and faded into the background where the data is collected but not given any meaning or thought:

> “I have a cadence sensor; I have two cadence sensors, actually. I’ve got a fixed one on one of my bikes, and I’ve got one which I can attach to my shoe, and I tend to use it every time I ride, but I never really look at the data. It’s one of those things where I’m not really sure; it’s just because I started doing it. I’ve continued collecting the data, but I never really give it any thought. You know, I look [at] heart rate stuff, I look at

> power, and I look at other kinds of things with quite a lot of interest" (Max, 52).

> "I used to use cadence the cadence on it to try and improve my performance, but I don't tend to use that so much […] I got a bike with a power meter on, which is, kind of gave me more information, I'm not using that bike anymore, but it got me out of using the cadence." (Greg, 57).

Cyclists and their technological assemblages continuously (co)evolve with new technological developments and their associated socio-technical practices. These developments in technology and its availability to the mass cycling market enable the (co)evolution of their cycling practices as new technologies are subsumed into the pursuit. While smartphones were replaced with dedicated GPS devices due to increased reliability and, in some cases, durability, sensors are upgraded to acquire better and more detailed information, information that can inform their cycling and help users to better understand and quantify the stresses the body is experiencing throughout their rides. Despite new technologies providing users with greater insights and self-quantification users like Max and Greg above continue to habitually collect the data. Data that they do not necessarily use but feel compelled to collect due to their inherent digital imperatives.

For many cyclists, their relationship with the technology progressed onto recording and monitoring their heart rate through chest strap monitors connected to dedicated GPS devices or wrist monitors integrated into GPS watches. By using heart rate monitors, cyclists can effectively make decisions during their rides based on the information they are seeing (Friel, 2009). As discussed in section 3.3.4, heart rate monitors have become more widely available and accepted as a standard biological metric that is important for training cyclists.

> "I had an old running watch that was a Garmin, but it didn't have any heart rate monitoring data on it, which [I] was really keen to see what

> zones I was working in when I was working out on the road bike specifically again so the heart rate monitor on the wrist was certainly a big step up in terms of getting something that actually tells me what my heart was doing" (Charlie, 26).

Charlie upgraded his device to get a watch with an inbuilt heart rate monitor. Technology is ever-developing; Charlie had an older watch with GPS functionality, but it lacked the ability to track biological feedback. Just as Strava alters scripts to retain user engagement, technology adapts and adds new functionality dependent on what users want, not only to increase engagement but also increase sales. The quote from Charlie above shows how this development of technology encouraged him to upgrade his device. Charlie wanted to capitalise on this newer technology as it afforded him new ways in which he could quantify his own performance and visualise his performance through heart rate zones. Heart rate zones are an important aspect in training as they can inform cyclists of the type of effect their riding is having on their cardiovascular system. Charlie had a thirst for more data and as a result he invested in his new watch. The heart rate monitor was able to inform Charlie about how he was performing while he was out cycling, and by using heart rate zones, he can be more specific about the type of training he does. This is also true for Debbie (44):

> "Depending on the type of ride I'm trying to achieve will depend on what I'm using it for. So, if I'm after a Zone 2 ride I will use it for heart rate and I will literally just focus on heart rate for the whole way round, don't care about average pace, don't care about anything. I'm trying to get my heart to stay in a certain level." (Debbie, 44).

Heart rate monitors allow cyclists like Debbie to closely monitor their effort and actively change what they are doing. Debbie stated how during a Zone 2 ride she is actively trying to keep her heart rate within its desired range. Her heart rate has become her sole focus, where the rest of her digital information and physical spaces fade into the background. The use of heart rate zones in this regard has simplified Debbie's training to a range of numbers that mediate her interactions and alter how she interacts with the physical environment. Her heart rate monitor allows her to quantify what would otherwise be unknown (Lupton, 2016b). By monitoring their heart rate, cyclists (co)evolve with their technology and begin to alter their socio-technical assemblages. While heart rate zones are useful for training there are times when they become ignored. Olivia (37) stated that heart rate zones have no effect on her physical output in certain circumstances:

> "If I was on a race, probably not. Because yeah, it was. Your heart rate is going to be whatever it needs to [be] for you to stay in the position you want to be. For training, I did quite a lot of zoned heart rate training, so yeah, I would go out, and some of the prescribed ones would be 15 minutes at zone 2, 10 minutes at zone 3. That side of things, I was actually using the heart rate function to check what zone I was in" (Olivia, 37).

Charlie, Debbie, and Olivia's quotes help to illustrate how the incorporation of heart rate monitoring technology has enabled cyclists to be better informed about their training and altered their physical interactions with the environment. Collecting heart rate data feeds into Strava's fitness and freshness features explored in section 6.15.3. Features like this also encourage users to actively engage with self-quantification and collect biological data. These developments in the availability of technology have allowed cyclists to develop training plans and pursue specific goals within their cycling (Friel, 2009; Millington, 2018). The specificity of training is important in helping cyclists to become fitter and stronger, and this is aided by the incorporation of heart rate monitors. However, their use within a race setting is not as important as Olivia stated. During race environments, cyclists are giving an all-out effort, focused on maintaining or improving their position rather than staying within specific zones. This is also confirmed by Emily (28), who, when racing, would see her "heart rate was at 200 beats a minute [and] I'd probably chill out a bit […] well, yeah, I'd tell myself I ought to, I'd probably just carry on".

Despite its usefulness for those taking part in competitive cycle racing, heart rate is viewed differently by some cyclists. As a result, the relationship that is developed between the cyclist and heart rate technology is situated within the context in which it is used (Shove and Pantzar, 2007). Interviewees reported that their physical responses to their heart rate data were generally minimal. Some cyclists reported that if they saw their heart rate was particularly low, it would encourage them to try harder. Aside from this, they tracked their heart rate to ensure that they were fit and healthy. This builds upon Lupton's (2014a; 2014b; 2016a; 2017) work of self-quantification and Millington's (2018) idea of Fitness 2.0, where technology is used to monitor their overall health. This is emphasised by Reece (39):

> "Mostly, it's just sat there tracking data and information. I sometimes leave it on the heart rate page to see, you know, if I am, and with the E-Bike as well with power modes so that you know, is my heart in a region where it's going too high or it's hardly doing anything with the heart rate and it's showing the different colours or the different beats per minute, you know, I think it's pretty easy [to] turn off the motor, give it a good push, get the heart pumping, get everything going and enjoy it, but, generally it's just to track information" (Reece, 39).

Sixteen of the respondents agreed with the sentiments expressed by Reece; they had an interest in how their heart was performing and being able to monitor their fitness over time. Their use of heart rate monitors during exercise was reserved for specific situations. For Reece, seeing his heart rate was particularly low, he would "turn the motor off and have a blast" to increase his heart rate. Whereas for Robert (63), this was when his heart rate started to trend higher than he would like it to, and the technology informed him to "ease off a little bit".

In some instances, cyclists were unsure of how their fitness was being affected by their performances. These uncertainties were addressed by heart rate monitors. This allowed them to understand and monitor their fitness as it progressed. For cyclists like Eva (59), this was out of curiosity:

> "Heart rate I did because I was never really sure what my heart was doing, and I've noticed I don't do it obsessively but what I have noticed is that since I've been using technology on, over 2 years my, I know that my resting heart rate has gone down which is an indication that whatever I'm doing is probably doing my heart some good" (Eva, 59).

Whereas for Aaron (53), tracking his heart rate highlighted an unusually high heart rate:

> "About a year ago I, I thought it was going a bit high when I was, it was spiking at more than my maximum heart rate for my age quite regularly, and one of my mates said to me, 'well that's a bit high' so I was like, well, I've always had quite a high heart rate, you know, then looking at the stats, I've always been ten or fifteen beats per minute on average higher than the people I ride with […] I went to the GP and said, 'do I need to worry about this?' they said, 'no, probably not, but we'll give you a 24-hour ECG', and so I did a 24-hour ECG, went on a bike ride, and it went off, the results went off to a cardiologist, the cardiologist came back and said 'well it looks, but he had three ectopic beats in 24 hours so put him on beta-blockers'. So, now I take 1.25 milligrams of Bisoprolol" (Aaron, 53).

Eva tracked her heart rate and monitored how it affected her resting heart rate over time. Cyclists like Eva used heart rate to monitor overall trends in their fitness rather than using it to inform their decisions during their rides, like Phil (35), who wanted to "see whether my fitness was improving or not using heart rate as that kind of metric". However, the collection and recording of rides and uploading to them to applications like Strava leave users open to scrutiny and surveillance from their peers. While Strava allows users to analyse their own performances and quantify trends in their overall fitness, their peers and followers are also able to do the same. As seen in the quote above, Aaron was subjected to this level of social surveillance and alerted to potential health issues due to tracking his heart rate. Through tracking it, he had a rich history of heart rate data that he was able to take with him to his GP. Despite the health issues that it alerted him to he was also able to visualise an improvement in his cardiovascular health with his average heart rate maintaining a downward trend. Aaron was not the only respondent who was interested in their heart rate from a medical perspective. After a health scare, Reece (39) felt incentivised to monitor his heart rate and has “been very interested to know that my heart condition is getting better”.

Despite the benefits of understanding how their health is developing, heart rate monitors were used in various ways. Initially, with some interest towards training, but more commonly, they became used to monitor cyclists’ overall health and fitness. Friel (2009) talks about how integral monitoring athletes' heart rates is for a coach; he also notes that heart rates can be affected by circumstances beyond their control. Some of the cyclists interviewed also understood how the environments they cycle in can and do influence the reliability of their heart rate. As Craig (25) elucidates:

> “it has its drawbacks as well with the cycling because your heart rate can be so variable, you know, depending on the weather and you know, whether you’re cycling into a headwind, or whether you’ve got a tailwind, or whether you know, what gradient you’re on, you know, or even what bike you’re on. I could go and train on my gravel bike and have to work much harder than I would if I was training on my road bike purely because of the terrain you’re on.”

Much like their device counterparts’ cyclists are also complex data processors. Cyclists like Craig consider the environmental and physical factors that can influence their heart rate. While their rides are increasingly influenced by the data they generate rather than how they feel, these external factors of wind, gradient, and road surface are all taken into consideration. These elements are beyond the control of the cyclists, and as such, their heart rate is a digital representation of the effort they are expending. This results in a rider that is informed through a synergy of data and physical spatial interactions. Heart rate monitors allow cyclists to quantify their efforts, however, external factors and the cumulative fatigue experienced during their rides limit its overall reliability (Friel, 2009). These inconsistencies with heart rate led some respondents to seek more accurate representations of the effort they are expending. For cyclists wanting to train more seriously and track their improvements, power meters are considered the most reliable training metric outside of testing within a lab (Sitko *et al.*, 2020). Jacob (22) was keen to improve his fitness and training for racing:

> "I think it was the heart rate was, just, I was starting to get my cycling a bit more seriously at uni then I decided to whack it on and see how we go and just track more data. I feel like I'm a very numbers [driven] person, and then the power meter was something a couple of the uni guys had, and I was like, you know what, it's the next logical step really to take my training from here up to here [gestures with hand] so I got that, sort of, spent my money and yeah, haven't looked back" (Jacob, 22).

Once cyclists like Jacob started to use metrics like heart rate to quantify and inform their training, they soon started to realise its limitations. Power meters provide cyclists with the ability to be in control of their performance and removed the influence that external variables can have on metrics like heart rate (Friel, 2009; Sitko *et al.*, 2020). It emerged that the use of power meters within training was considered to be revolutionary. Many respondents agreed with the sentiments Jacob expressed that power meters were a good investment and are "the greatest training device you could possibly use" (Leo, 19). Many of the respondents were keen to express how valuable the use of power had been to understand their fitness and training, and allowed them to more accurately compare themselves to their peers:

> "I can understand now why people say, 'gosh I bought a power meter, it's completely transformed my understanding of training'. It really is completely different, training with a power meter because my heart rate is quite deceptive and also because my heart rate doesn't respond in quite the same way that I think training models suggest it should. I've

> got a very low maximum heart rate and quite a low resting heart rate, and you know, actually knowing the power output has been quite interesting in, especially in comparison with other people, so it's almost a tendency when you're training, for me, to think I'm worse than I am compared to other people based on heart rate or speed or whatever" (Max, 52).

A theme emerged from participants who used power meters within their training during the interviews. This theme was in the language they used when referring to power meters. This can be seen in the quote above from Max (52), who finally understood what his peers meant about training with a power meter. Notions of transformation, change, and specificity were used when referring to power meters. Although heart rate had been a useful addition to many of the cyclists' data analysis toolbox it did not have as much of a profound impact upon their performances as power. Max was able to train more appropriately as his power meter reacted more instantaneously to the effort he was producing. This was also mirrored in a response from Jacob (22), who said, "It's obviously a lot more effective to train with your power numbers than your heart rate because it [heart rate] just lags a little bit". Because of their renowned efficacy in training, participants often referred to more specific training workouts and regimes with their power meters. Jacob (22) explains:

> "Previously, I'd go out, I would just ride and then look at my heart rate afterwards; it sort of, almost, I've got the power meter now and almost with the change of mentality of how I'm cycling. It's like I'll go out, 'OK, I'm gonna do two blocks of 20 minutes at this power, and I'm gonna keep an eye on my heart rate at the same time to sort of see how it changes between the efforts, and I feel like the power meter has made me more number focused while I'm out cycling."

This indicates that for some cyclists, the use of and their reliance on the technology has (co)evolved with it. Their experiences are produced through the technology as opposed to with it. Jacob above described going out cycling with a new "mentality". His workouts were becoming more specific. The “blocks” Jacob referred to are more commonly known as interval training. These intervals are often ridden at higher power outputs for a specific amount of time (intervals can range from 1 minute to 20 minutes and in some case 40 or 60 minutes) with a period of recovery in between where cyclists ride at a lower power. Power meters are well suited to this style of training as they accurately quantify the effort in real time (Sidwells, 2019). This means that power meters are an influential piece of technology that are able to change the way cyclists ride and train but help them understand how they are riding.

> “To be honest, I didn’t know, kind of, how my riding style was really until I started using it, so like I, when I was younger, I used to go and do training rides with the local group, and those to me were very difficult to start off with and as my fitness increased, I kinda thought that tempo was quite easy and then when I finally got my power meter working, and using it properly I realised I was riding every ride as hard as I could and not actually giving myself time to recover. So, I was pretty good for 2 hours, but anything after 2 hours, I’d already knackered myself. So, like, now I can actually go for a ride; that was quite a few years ago, though, now I can just happily go for a bike ride and understand that I’m not actually exerting myself to the same level that I was and still be able to recover, gain fitness, and ultimately improve my ability as a rider” (Leo, 19).

Leo’s response summarises just how useful power meters are in providing an overview of cyclist’s fitness. Until he started to train with power, Leo did not understand how he performed on each ride. The introduction of his power meter revolutionised his training and his understanding of his bodily performances. Where he had previously expended all his energy two hours into a ride, he was able to manage his energy and, as a result, ride further and longer more efficiently. Some interviewees had brief experiences with training with power meters, particularly on indoor turbo trainers, and due to their experiences of its usefulness, they considered a power meter their “next evolution” (Debbie, 44) in their training. Even cyclists like Jess (36), who had no experience of training with a power meter, understood that the benefits could help her focus her training and “probably get as fit but in maybe three-quarters of the time” than training without one.

Throughout the interviews and the quotes presented in this section many of the cyclists utilise biometric sensors to track their health. This allows the respondents to monitor their own health and fitness and allows them to visualise their performances through aggregated data collected over years of self-surveillance and self-quantification (Lupton, 2014a; 2016a). For some, this level of self-surveillance provides users with comfort in understanding how their bodies are performing and developing over time. In this case, biological data captured transforms subjective bodily understanding into, as Lupton (2013: 266) states, a “’metric’, privileged for its objectivity and the presumed insights it can provide”. While many of the participants collected biological data out of interest in some select examples, the technology alerted them to seek medical advice (Aaron, 53) and to monitor their health after an unresolved medical incident (Reece, 39). For those who tracked their heart rate, it was used during rides to encourage them to try harder when it was particularly low as they were “doing this [cycling] for exercise” (Greg, 57) or to “ease off” (Robert, 63) when they were cycling too hard.

Cyclists’ rides have become increasingly mediated through technology. This has been evident within the interviews as many of the respondents recruited a network of sensors connected to their bodies and bicycles that digitised their bodily functions (Lupton, 2014a). Barratt (2017) suggests that technology has the ability to influence cyclists’ practices and that these technologies are reconfiguring the everyday practices of cyclist’s movements (Schwanen, 2019). It is clear from the interviews that technology is changing the ways in which cyclists engage with the practice of cycling. This has been most evident in cyclists who actively engage with specific training plans, whether for the purpose of racing or just improving their fitness. Power meters, in particular, have had a profound effect on how cycling is performed, with cyclists sticking to rigid training regimes where their bodily outputs are conducted through the numbers displayed on their dedicated GPS devices. The functions of cycling technology changes over time. While heart rate was once considered to be an integral part of cycling training, it has been replaced by power meters. With new developments in technologies and their proliferation within cycling, they become imbued with new meanings and are subsequently subsumed into requisite practices. 37 out of 38 of the cyclists sampled had incorporated some form of bodily sensor into their cycling practices, and in some cases, they were seeking other means of quantifying their performances. At the time of the interviews, power meters were the next logical step in understanding their training; however, more recently, blood glucose monitoring has started to become a popular form of biometric feedback amongst cyclists who are keen to understand how changes in their eating habits (pre, during, and post-ride) can affect their rides and recovery.

6.18 Technologically routinised cyclists

This section explores the routines of cyclists and their relationships with the technologies that influence and create their rides. For many respondents' technology was present pre-, during, and post-ride, which illustrates that technology forms a significant part of their cycling routines. Although it varied for each respondent, there was a consensus that while getting ready to head out cycling, turning on their dedicated GPS devices was an important part of these routines. The following quotes from Ryan, Olivia, and Aaron emphasise how technology has become routinised within their cycling practices:

> "Pure athlete: kettle on brew, get the bike out – quick check it over water bottle, couple of water bottles maybe, Garmin on switched on so it's acquiring its satellites so it's ready to go as soon as the wheels are moving, bottles in and away we go" (Ryan, 51).

Ryan's quote illustrates that technology is factored into his pre-ride routine. Ensuring his GPS device is ready to go is as important as ensuring he has water available for the ride.

> "So yeah, sort of prep for any food and water that I'm taking chuck that on the bike or throw it in the camel back, yeah take my phone, normally take like a bank card or something like that depending on how long I'm

> going out, whether we plan to stop anywhere, then yeah, grab the bike before I take it downstairs – they live inside now – put a Garmin on either pre-program the route on that the night before or that morning yeah, head downstairs, hopefully press play and off I go really. So yeah, it's certainly part of the routine" (Olivia, 37).

Technology for Olivia can be factored into her pre-ride routines the night before to ensure that she has downloaded her route ready for her ride. Similarly to Ryan, Olivia also ensures she has the device ready to go as she leaves the house.

> "So, well, make sure everything's charged up. When I set off, I'll pop the Garmin on the bike turn it on, get signal before I leave, make sure the phones connected so it's definitely part of that sort of, pre-ride, have I got everything? Is it all working? Are my lights on? Have I got my phone? Just as much as putting your gloves on, and your glasses and helmet, you're popping your Garmin on and making sure it's connecting with those lovely satellites" (Aaron, 53).

Much like Ryan, Aaron turns on his device before he leaves the house to ensure that it is connected to the "lovely satellites" and ensures that he can start recording his ride as soon as he is ready to go. These quotes show how dedicated GPS technologies and additional sensors are an integral part of cyclists' routines that require attention before the ride is able to take place. Technology is considered by respondents to have become part of their routinised practices and had become normalised within cycling cultures. As discussed throughout this chapter, cyclists have embraced technology, and their experiences have been enhanced by its use. Shove, Pantzar, and Watson (2012) state that practices emerge through the linking of elements, and they persist by becoming embodied within the experiences of practitioners. Technology has become widely embraced by cyclists and has become an increasingly popular way of improving and quantifying their abilities. Strava and its associated technologies have become a prevalent part within cycling as they have been able to transcend beyond just a means of quantifying performance and cross into the realm of a bespoke social media platform (Millington, 2018).

Technology and Strava having an integral part of socio-technical cycling assemblages was a popular theme amongst the sample of cyclists interviewed. Many respondents felt that technology was implicit within cycling culture. Matt (55) suggests that "you're hard pushed to find a cycle group out on a weekend without the technology". The sentiment that riding without technology is not a normal thing to encounter is also expressed by Ryan (51), who said:

> "I've been riding with the club for about 4 or 5 years. It's a Garmin, a Wahoo, or whatever bolted to the front of the bike is just as commonplace as someone riding with a helmet. It's the norm; everybody in the club has it, uses it, and uses some sort of recording device. There are, I do ride with a few people that don't, that are old school, but that's very much not the norm."

This quote from Ryan expresses that although there are a few people, particularly older cyclists, that do not use technology, it is a vast majority that subscribes to technologised practices. Ryan also states that the use of technology is as "commonplace" as wearing a helmet. This was also expressed by Aaron in a quote above as well as by Bill (61) who stated: "it's about akin to wearing a helmet". The notion that using a device to record rides is just like wearing a helmet is reminiscent of Michael's (2000: 3), who contends that "mundane technologies have lost their novelty and now linger in the background". Although some of the technology used could not be considered mundane, the devices that facilitate the recording of their activities certainly fade into the mundanity of their everyday cycling practices. In this regard, cycling technology, like dedicated GPS devices, has become subsumed within cycling practices, and its use and functions have changed over time (Shove and Southerton, 2000). Several respondents, like Neil (44), stated that technology had "just become second nature" and was considered to be part of their habitual cycling practices. When asked whether she used the technology out of habit, Olivia (37) responded by saying:

> "Probably, yeah. It's something that I've sort of grown to use all the time, and like I've said before, that yeah, it feels a little bit odd if it's not there and you can't look at it afterwards, and I think we're certainly in that era now where everything you do you either take a photo and post it on Instagram or it's recorded on some sort of data capture app whether that be Strava or something like that. So, I think we're certainly in an element now where everybody's into that and just recording what they've done, so it is sort of a habit at the moment."

Olivia highlights the fact that cycling is becoming increasingly mediated through technology is also reminiscent of the fact that everyday life has become technologised. Olivia mentioned that increasingly, every moment of life is digitally recorded and shared through an application or social media, which is reminiscent of Ash, Kitchin, and Leszczynski's (2019) notion that the digital has permeated into every facet of daily life and, as such, cycling is no different. Olivia continued that if she forgot to take her device, she would be "gutted if the ride didn't exist", stating that the "ride didn't happen if it wasn't on Strava". Technology is an extension of Olivia's experiences and has become an essential part of the ride that is "instrumental in the reconfiguration of our conceptions of the social and of nature" (Michael, 2000: 3). While the ride can occur without technology, the enjoyment and experiences are entwined within its digital mediation.

For other cyclists, their experiences of cycling without technology are similar to Olivia's. They value the presence of technology within their rides. Chloe (28) emphasises the frustrations she would feel if she forgot her device:

> "I would be upset and very frustrated, I would still go on the ride, but I'd probably just borrow her recording. And if that wasn't an option, I might even just log it, only for me to see, but just so that my activity log has got the, what I've done because I do like the activity log on Strava that

> heat maps out your effort for the week. But, yeah, it would upset me a great deal."

Chloe mentioned that she would feel very upset without a device to record her ride. She also noted that there are a number of ways for her to be included in the ride uploaded by a friend. This would enable Chloe to still keep track of the exercises she has completed for the week and update her activity log. Although the quotes above highlight how technology within cycling is becoming a mundane object within cycling practices such as helmets and water bottles, cyclists become more aware when the technology is no longer present. Feelings of disappointment and frustration occur when their devices are left behind, and time permitting, they "went back and got it [device]" (Jacob, 22). While there are solutions built into Strava, like the ability to share a ride with someone unable to record the nature of the frustrations are altered but not removed, as Sophia states:

> "I climbed Mount Teide in Tenerife, and when we got to the bottom, I think we'd done about 55 miles, and my Garmin crashed and lost my ride. And I'll be honest with you, I cried. I was mortified. And I was like, 'biggest mountain I've ever climbed', and my partner said, 'It's alright, you can use mine,' and I said, 'Yes, but it'll have all your records on there, not mine, so I'll never be able to beat them" (Sophia, 40).

The quotes above demonstrate that technology has changed the cycling experience, they have become integral to each part of the cycling routine, and when something goes wrong either with a recording or by forgetting a device, they leave cyclists with a feeling of frustration. Chloe stated that she would still go ahead and ride in the absence of technology but that, ultimately, she would be upset with not having that recording available. The functionality of the technology was something that was important for the cyclists interviewed. Bad experiences with technology failing, like for Sophia, could have an effect on their overall perception of the ride or the technology itself. The socio-technical practices of cyclists have (co)evolved with each performance (Hand, Shove, and Sotherton, 2007); this has been reflected through the narratives of the participants and expressed in the quotes above. Technology has become normalised, inherent, and an integral part of the practices of cyclists, and much like the fridge freezer redefined domestic practices and daily routines of 1970s housewives, GPS-enabled devices have redefined the routines and practices of cyclists.

6.19 Summary

This section has shown how the cycling assemblage has become digitised and how the enactment of cycling has become a digital pursuit. Cyclists' rides are created through their dedicated GPS devices and uploaded to Strava, where their experiences are augmented through digital representations of physical spaces (Leszczynski, 2019). Cycling practices and their varied engagements with technology have developed emotional and associated meanings that have been imbued upon the technology. This has resulted in technology becoming integral to the (co)production of spatial experiences of cyclists. Cycling is no longer and ephemeral act as digital tangible artefacts allow the ride to live on.

Throughout this section, the use of digital devices and the digital artefacts they create have been explored. It has become apparent that their use has become subsumed into the socio-technical practices of 37 of the 38 cyclists interviewed. However, the technology and its effects are dependent upon each individual and the situations in which they use the technology. Older cyclists, particularly those who have cycled consistently since childhood, have experienced the development of technology through their cycling life and have actively embraced new technology as it becomes available. This is because although specific technologies are designed with particular use cases, cyclists imbue their own meanings upon it. For those actively competing in cycle racing, technology enables them to train more specifically, whereas for others, it can provide external motivations to maintain their fitness. Through self-surveillance and self-quantification, these technologies provide them with detailed insights into their overall health and fitness. It was also evident that as newer ways of quantifying bodily functions became available, previous technology faded into the background of their practices, but their digital imperatives meant that the data was collected nonetheless.

From the interviews, it is clear that Strava increased the motivations of cyclists. The gamified aspects of the application, like its segment feature, were a great motivator for cyclists to improve their own times or beat that of their friends or even strangers. Segments had largely been considered as a retrospective part of the experience, with cyclists reporting they felt upset when they did not see any improvements in their times or a lack of personal records. However, the challenge feature did not have the same effect as segments. While segments create active competition in themselves or against others, the challenges are not actively sought out. Cyclists habitually took part in them but were not as actively engaged with them like segments.

For the cyclists interviewed who had a Strava Premium membership, there were enhanced training features that were unlocked. These were used to varying degrees by the cyclists, but once more, they were linked to increases in motivation. The training log provided users the ability to quickly see an overview of the amount of training they had completed, as well as allow cyclists to further relive past activities that they had enjoyed. Strava also provided these users with relative effort and fitness and freshness metrics. For one particular respondent, the relative effort score led to negative impacts to his health as he tried to get the highest score he could on every activity. This was certainly not the norm, as many of the respondents felt these metrics helped them to quantify their fitness over time and helped them factor in when they needed to take a break or go easy on their training.

As the technology improves and new devices come to market, the socio-technical assemblages also (co)evolve. The (co)evolution of their practices results in changes to the constituent elements within the practice. As new objects and technologies become available, they are recruited into the practice and with each (re)enactment, they are ascribed new associated meanings (Hand, Shove, and Southerton, 2007; Shove, Pantzar and Watson, 2012). New technologies, therefore, can directly affect human practices but are reliant upon repeated human interactions to develop as a practice (Latour, 2000; Shove, Pantzar, and Watson, 2012). Practices change over time, and so to do the relationships with technology as they become normalised and habitualised into their routines (Shove and Southerton, 2000; Hand, Shove, and Southerton, 2007; Shove, Pantzar, and Watson, 2012).

Technology also enabled cyclists to quantify their bodily exertion, transforming what was previously speculation to the known and quantifiable. Self-quantification is present throughout cyclists' experiences with technology. Current technology has allowed cyclists to train with greater specificity, recover more efficiently, and understand the impact their training has on their fitness over time. Their views on technology illustrate how integral it is to completing their practices, particularly for specific training regimes, as it enables them to immediately complete a pre-constructed workout through on-device digital readouts and displays. Cyclists' technological assemblages allowed them to feel empowered by their biometric feedback that relates directly to Lupton's (2014a; 2016a) notions of self-quantification and increased their motivations overall (Chen, Zdorova, and Nathan-Roberts, 2017).

Cycling has a rich history of technological advancements. Despite the bicycle remaining vastly free from drastic change within recent history, cyclists have inherently sought out new technologies. The historical development of bicycle technology represents how technological developments are embraced by cyclists. As the technology is embraced cyclists enter into new socio-technical assemblages and develop new skills and competencies. These new skills and competencies are (co)produced with each (re)enactment of their practices (Shove, Pantzar, and Watson, 2012). Through these subsequent (re)enactments, the technology becomes subsumed into the act of cycling and forms an integral part of the socio-technical assemblage. Much like everyday life is mediated through mundane technologies that have faded into the background of daily practices cycling technology has also become considered as mundane (Michael, 2000).

New practices are formed by cyclists to ensure that their technologies are ready to go as soon as the pedals turn. Devices are charged overnight or at the end of each ride and switched on while cyclists are getting ready to ensure they have locked on to satellites. Power meters are calibrated, and heart rate monitors are put on. Technology has become a normalised part of their pre-ride routines and provides them with real-time knowledge of their performances, and the digital artefacts created from their recording allow them to relive their ride after it has ceased. These technologised practices shape cyclists' experiences. Technology has the ability to directly affect their emotions, particularly when it does not work the way it is intended. Technology changes their bodily interactions with physical space either through augmented realities competing for kudos on online leaderboards or through their bodily sensors encouraging them to push harder. The cyclist is enhanced through their technology. Physical spaces are still important to the enactment of cycling, but digital technologies have enhanced the participation and motivations of its users (Barratt, 2017; Millington, 2018).

To summarise, technology forms an integral part of cycling practices. Cyclists are technologically integrated assemblages of biometric sensors and satellite-enabled GPS devices. Cyclists' narratives illustrated that their experiences of cycling were contingent with the presence of the technology that had become subsumed into their practices (Hand, Shove, and Southerton, 2007; Shove, Pantzar, and Watson, 2012). These technologies have become imbued with meanings of motivation and enjoyment that have allowed them to become enmeshed within the embodied experiences of cycling (Barratt, 2017; Shove, Pantzar, and Watson, 2012). As practices are reliant on continual (re)enactments for their survival technology is continuously (re)shaped by and (co)evolved within the socio-technical practices. Thus, in accordance with Ash, Kitchin, and Leszczynski's (2019) Digital Geographies and Shove, Pantzar, and Watson's (2012) examination of everyday practices, cycling and cycling technology have become enmeshed with each other and the practices of cyclists are affected both on and off the bike as they engage with these technologies.

6.20 Summary of all sections in Chapter 6

These sections have explored the complex and nuanced relationships of cyclists and their technology. These socio-technical assemblages have been examined by looking at the individual parts that form the wider practices. First, the chapter explored how the requisite skills for cycling were acquired at a young age and how the associated meanings with cycling are fluid. This highlighted that cycling as a pursuit and as a practice is already subject to evolutionary changes with its practitioners as it is recast with new meanings as and when cyclists leave and return to the pursuit. This section explored how those meanings change from that of freedom as a child to reflect those of utility required for transportation in early adult years and then onto meanings of health, leisure, and fitness.

Second, the mediation of cyclists was examined. This involved looking at the development of cycling applications and how the invention of the smartphone facilitated a digital turn in cycling. This included the consideration of the smartphone and subsequent development of applications as a gateway for new and old cyclists to be recruited into the digital practices of cycling. However, smartphones lacked the ability to fully record longer rides, and as a result, cyclists sought out more reliable means to track and quantify their rides in the form of dedicated GPS devices. Cycling became (co)produced through these digital technologies, and cyclists have become continuously connected through them (Wilson, 2014).

Finally, the chapter discussed how technology affects cyclists' rides through means of gamification and quantification. Gamified technologies like Strava segments and challenges are linked directly to their motivations. Segments have been used to assist in specific training as well as encourage cyclists to pursue a faster time on digital leaderboards. This section also explored how digital sensors turn bodies into binaries. Heart rate monitors and power meters are used by many cyclists as a means to understand how their body is performing and directly affects their physical outputs during the ride.

Chapter 7 discusses the implications digital technologies have had upon the practices of cyclists. This chapter also considers the digital imperatives that are imbued upon cyclists through the incorporation of digital technology into the practices. It also highlights moral and ethical issues that need to be considered to ensure that gender disparities are not exacerbated by scripted applications.

Chapter 7: Discussing socio-technical transitions in cycling

7.1 Introduction

The empirical chapter illustrated that cyclists are digitally mediated socio-technical assemblages whose experiences and motivations have become intrinsically linked to their technologies. Cyclists are motivated through application scripts that augment their experiences through gamified interactions and constant self-surveillance that allows users to track, log, and quantify their rides. Cycling has received much attention within contemporary research, particularly around debates in active transport. It is evident from such debates and this research that technology plays an important role within the motivations of cyclists. Not only have cyclists found that technology increased their motivations, but it also creates a compulsion to record data, which in turn leads to the routinisation of cycling habits that extends to active consideration of replacing car journeys and commuting. Cycling has many benefits; it is a sustainable mode of transport with few adverse environmental impacts and can be used for active leisure and transport with the associated benefits to health and well-being. This has resulted in cycling being of great contemporary importance for policy makers and researchers alike (Aldred, Croft, and Goodman, 2019). Since 1993, participation in cycling has been increasing (Cycling UK, 2019), with a sharp rise post-Olympic games in 2012 (Aldred *et al.,* 2015; British Cycling, 2015). Despite this increase in popularity, there are still disparities between cycling as a leisure pursuit and as a form of transport (Aldred, 2015; Lamont, 2009).

More recently, there has been burgeoning research into the digitisation of health and associated health applications. Particularly Millington (2018) and his ideas of Fitness 2.0 and Lupton's (2016b) notion of self-quantification. The incorporation of technology has encouraged cyclists to cycle more frequently and even begin to replace car journeys. Applications and GPS-enabled technologies used by the respondents support the idea that cyclists' motivations are increased and that technology is responsible for it (Barratt, 2017; Rivers, 2020). What much of this contemporary research lacks is an understanding of why and how the practices of cyclists have changed. The gamification of cycling through application scripts inherent in Strava is responsible for facilitating changes in cyclists' practices, though it is not the sole actor within these changes. Motivations towards exercise can be influenced by psychological and sociological factors (Chen and Pang, 2012) and increased motivations towards exercise, particularly cycling, has positive impacts on life satisfaction and subjective well-being (Xu, Yuan, and Li, 2019). However, while motivations for cycling have been addressed in Chapter 6, the wider implications of these changes are yet to be discussed. Technology is part of the practices of cycling and has produced cyclists that are prone to increased motivations to ride their bikes, are conscious of wider health effects, and can influence their everyday lives. This chapter continues by focusing upon the themes raised within Chapter 6, particularly how technology has increased the participation and motivations of cyclists and discusses how using practice theory to unpick the practices of cyclists, an approach which can then be applied to wider applications to understand technologised practices and encourage the pursuit of active leisure and transport.

7.2 Structure of the chapter

This chapter considers how technology shapes the motivations of cyclists and its implications within the growing role of active leisure and transport research. Although there are many facets to the technology used by cyclists that can elicit individual effects on them, this chapter considers the broader changes to practices that have been caused through the increased use of technology. First, the chapter considers the role of cyclists within this research. By using practice theory, this research can be replicated to understand the motivations and practices of other digitally-mediated pursuits, as well as be applied to further policy initiatives exploring the roles of gamification in increasing intrinsic motivations. Secondly, the chapter examines how technology has generated changes within cyclists' practices. Users reported that Strava added something extra to their cycling and that they would cycle less without Strava and the associated technology. This section also considers the effects that self-surveillance has upon users and the negative effects that can arise. This examines how cyclists are encouraged by technology to over-train and even develop signs of exercise addiction. Familial conflicts are also considered, as these increased motivations can lead to selfish tendencies, causing gendered health inequalities and tension within the household dynamic. Third, the gendered nature of cycling and sport participation is examined. This section further explores how gender disparity is already present within sport and how applications like Strava and its inherent gamification can reinscribe traits of sporting masculinity. Next, the chapter discusses how the increased motivations of cyclists encourage them to actively replace car journeys and identifies how this is useful for further research into active transport research and policy. Finally, the routines of digital leisure practices are considered and how the intense, gamified experiences highlighted within this research can be used to explore how digital technologies are used in other sport and exercise pursuits.

7.3 Unpicking practices: cycling as a case study

Cyclists' relationships with technology have a rich and heterogeneous history with regard to technological developments (see Chapter 3). These histories range from modifying early bicycle designs to make them go faster to developing ways of quantifying their cycling through rudimentary mile-o-meters. Thus, cyclists are ideal candidates for research into technologically-mediated practices. There is a wealth of cycling technology available that offers cyclists insight into a multiplicity of biometric, mechanical, and digital data to routinely pore over during their post-ride analysis. Initial research from Barratt (2017) found that applications like Strava have the potential to change cyclists' practices. To further understand these changes, the research was underpinned by practice theory. Practice theory has been applied to mundane routines within everyday life (section 4.3), and the work of Shove, Pantzar, and Watson (2012) has provided a useful framework to better comprehend how practices emerge, sustain, and die. Their framework breaks practices down into three constituent elements – materials, competencies, and meanings – which allows greater insight into how practices are developed and then propagated between individuals. Practice theory has already been successfully used to "capture the dynamic aspects of social practice" (Shove, Pantzar, and Watson, 2012: 1) such as showering (Hand, Shove, and Southerton, 2005), the increased use of fridge-freezers (Hand, Shove, and Souterton, 2007), and the (re)invention of Nordic walking (Shove and Pantzar, 2005). As such, practice theory was chosen to understand the dynamic, nuanced, and, at times, contradictory narratives of cyclists.

Cycling has been subsumed by technology. Lightweight bikes, digital cycling computers, biometric sensors, and associated applications are continually being developed. This research was developed to understand the dynamics of socio-technical changes in cyclists. Practice theory is well suited to understanding such socio-technical changes by breaking down practices into their constituent elements. Elements can then be examined individually and how they have (co)evolved, (co)developed, and been (co)produced with, and through shared practices, and have become entrenched within cycling. As digital technology has already become embedded in wider everyday life (Redhead, 2016), research has started to unpick how it alters practices and mediates wider interactions within physical space (section 4.4). Chapter 3 identified how cyclists and their cycling assemblages have been particularly involved in the development and quantification of cycling throughout history. This was also evident in section 6.10, as respondents have also been proactive in embracing new and emerging technologies. This perceptiveness to technology was also clear in section 6.11, where respondents were proactive in utilising emerging cycle tracking applications as they rose in popularity initially on the iPhone App Store and later Google Play Store.

Practice theory provides the ability to understand the mechanisms that result in societal change. In their book *“The Dynamics of Social Practice”,* Shove, Pantzar, and Watson (2012) use a number of examples to explain how practices emerge and die. They also explore how practices can share elements with other practices. As a result, new practices can develop from old practices, or can inform how the formation of new practices. As technology has developed and increasingly mediated, everyday life practices have altered to embrace new materials that facilitate digital interactions. In particular, social interaction has become increasingly mediated through a series of online social media platforms (Ash, Kitchin, and Leszczynski, 2019). Strava has become one of the most popular cycle-tracking applications, and this has been in part due to its sociability (section 7.4.1) and gamification scripts (section 6.15).

Cycling is a complex network of practices that involve the practice of cycling itself, practices of self-quantification, and, more recently, the creation of digital artefacts. Although cycling can be considered as a bundle of practices, this thesis and its empirical discussions have focused more intricately on the digital practices many cyclists now participate in. Examining the socio-technical assemblages of cyclists to explain how technology shapes their practices. As this thesis has explored, Strava and dedicated GPS devices have modified the practices of its users, becoming a new distinct practice amongst many cyclists. This distinct practice is contingent on devices and applications like Strava, where cyclists are able to (re)produce tangible digital artefacts of their rides and transform them from an ephemeral experience into a relivable tangible thing (Latour, 2000). Cycling is not contingent on these new digital practices. Nor do all cyclists participate in them. For many, particularly those interviewed, these practices have become part of their daily routines. They have built upon previous practices and meanings of self-quantification that are the successors to previous iterations of technology that simply counted miles (section 6.10). It is also evident that cycling and cyclists can alter the meanings ascribed to cycling itself (section 6.7).

Practice theory was used to identify concepts that can be applied to wider debates surrounding active leisure and transport as well as getting people more active generally. The approach enabled the research to unpick cycling and digital cycling practices through semi-structured interviews and detailed qualitative analysis. The empirical discussion in Chapter 6 centred around the narratives of cyclists who were digitally engaged with applications like Strava and dedicated GPS devices. These digital practices are distinct from their original practices of cycling. Their ability to record, track, and analyse their rides has become its own routine within their cycling practices. Many of the interviewees experienced a digital creep whereby their digital routines encouraged them to invest in more technology, such as power meters, heart rate monitors, and activity trackers. Respondents often regularly engaged in other sporting activities, predominantly running and swimming. During the interviews, participants often changed freely between the pursuits they engaged with and reported about how their practices are influenced by the technology. Their use of technology was, at times, different between pursuits, with some reporting that purchasing a GPS-enabled watch for running enabled them to leave their smartphone at home or that it provided them with better accuracy for recording their activities. For others, it was purchasing a GPS-enabled cycling computer so they could see real-time data during their rides rather than have to check their smartphone or watch.

Furthermore, practice theory allowed the research to understand what meanings are imbued onto the gamified aspects of Strava (section 6.15). This research has found several changes that have occurred since Barratt (2017) identified Strava's ability to influence cyclists' motivations. This shows that cyclists' digital practices are continually (co)evolving. Yen, Mulley, and Burke (2018) stated that gamification is a "supportive way to meet policy goals" but that current initiatives have fallen short of creating long-term sustained changes to practices. A practice theory approach is also applicable to research like that of Coombes and Jones (2016) when analysing the impact of *Beat the Street* in its ability to increase active school commute participation. Understanding how the practices of cyclists have been changed through gamified applications is of contemporary importance going forward, and a practice theory approach is useful to ensuring the success of policy initiatives aimed at increasing participation in active leisure and active transport.

7.4 Changing practices: cyclists' digital imperatives

Strava was conceived to digitally enhance the experience of solo cycling (Barratt, 2017). The application sought to replicate the social experiences of club and group rides through its online digital interface. Although Strava did not set out to change its cyclists' practices, it has become evident that changes have occurred (see Barratt, 2017; Barrie, Waitt, and Brennan-Horley, 2019). This research has highlighted that the changes that Barratt (2017) reported have since (co)evolved. This means that Strava's scripts, their interpretations and meanings to users are fluid, (co)evolving, and (co)produced with each other. There have been evident changes in how the technology that augments physical experiences of space, like Strava's segment feature (section 6.15.1), challenge features (section 6.15.2), and the digitisation of bodily functions (section 6.17), are used.

Scripts like Strava's segments, challenges, performative quantification, and self-surveillance can be considered as core elements to Strava and that have the biggest effect on technologised practices both on and off the bike. These individual elements affect cyclists in different ways; this is not only evident between genders but also within genders. These technologised practices are considered as a whole and what implications they have had on cyclists not only on their cycling practices but also within their wider everyday lives. Overall, respondents felt that their motivation towards cycling had increased, and they felt encouraged to ride more frequently. A compulsion to record their rides and track their data had led some respondents to incorporate their bike into mundane tasks of everyday life like commuting, visiting friends, or running errands. Conversely, the presence of technology had also had negative effects on cyclists' experiences whereby they became concerned with how their rides would be perceived by peers.

The implications of cycling with technology are apparent. It could be argued that cyclists have become "cognitively corrupted," like Michael's (2009: 91) hill walkers and their mobile (cell) phones. However, as the following sections will discuss, Barratt's (2017: 334) notion of a "digital imperative" is more appropriate. Exploring the changes in respondents' practices showed that their motivations had been altered through Strava's scripts. The research shows that these digital imperatives can become compulsions to record and track data regardless of whether it was actively sought, personal and social pressures to exercise, and, in severe cases, lead to familial disputes.

7.4.1 Digital imperatives: an extra dimension

> "I think it's added an extra dimension to it personally. I think also I'm more tempted to go out for a ride now than I would have been without that technology. Also, it makes, because I cycle mainly on my own and I'm not a member of a cycling club. I don't have that cycling community, apart from that, I know people that cycle, which is a lovely community, but I think the Strava community is also, I like that" (Eva, 59).

This quote from Eva emphasises that applications like Strava and dedicated GPS devices lead to an increase in cyclists' motivations. Respondents took part in cycling for various reasons, but a common theme that emerged from the research was that cyclists' motivations had been increased through their use of Strava. Like Eva, their motivations were increased stating that the technology encouraged them to ride more frequently than they would have without it. This shows that technology has directly altered the motivations of cyclists and is a reason for cycling more frequently. Motivations for engaging with physical exercise has been well documented within academic research, notably due to the benefits for public health (Goodsell, Harris, and Bailey, 2013; Lamont and Kennely, 2012). Improved health and fitness were inherent motivations held by ten of the respondents; however, there were also motivations representative of Leary's (1996) ideas of self-presentation. In this context Leary argued that perceived social identities influence a person's motivations for taking part in regular physical exercise. In doing so, they "gain a great deal of attention, praise, and other social rewards", and it "may also enhance one's social image" (Leary, 1996: 340). This further links into to gamification features of Strava. Notions of self-presentation and social image build on Barratt's (2017) findings of profile development. While he found profiles were used to gather information about other cyclists, this research found that profiles allowed users to understand their own cycling.

Many aspects of social life have transitioned to online spaces (section 4.4) (Ash, Kitchin, and Leszczynski, 2019). Similarly, Strava was created to provide cyclists (and runners) with the sociable aspects commonly associated with group rides during solo training rides (Wallace, 2012). Strava initially attempted to digitally recreate the experience cyclists felt when sharing their physical experiences of cycling in groups. For cyclists like Eva who have no affiliation to a club or do not ride regularly with friends Strava *is* the community. Eva predominantly cycles on her own. As such, Strava provides her with the camaraderie that is associated with group riding; she can communicate with other cyclists and give them a virtual thumbs up. In section 6.15, Eva talked about naming her rides and creating a story or diary entry. In this regard, Eva is creating an online community amongst her cycling friends and uses Strava to provide rich digital artefacts of her physical experiences. Strava provides her with a social belonging. This is further supported by the work of Chen and Pang (2012), who noted how sociological factors had an impact on people's motivations to take part in the exercise. More recently, Rivers (2020: 6) conducted a discursive study and found that sharing rides online with a like-minded community was essential "to the transformation from a solitary experience to a mediated communal experience". Despite Rivers (2020) noting that social engagement encourages users to ride more frequently, pressures and anxieties can also arise among users, something that was not considered in his research. Brian (34) explains his experiences of sociability on Strava:

> "I think it makes me feel more accountable for my ride because there's that social pressure being put on Strava, so there's that constant thought about trying to make the numbers look as good as possible [...] once I started feeling that social pressure that's probably a big driving force for me [to ride more]."

Although users like Brian felt Strava held them accountable (section 6.14.1), he also noted that self-surveillance brought along with it performance anxieties. While users felt encouraged to upload rides regularly and actively sought to ride more frequently due to these social pressures. Strava imbues social anxieties onto users such as Brian. Brian expressed that he needed to ensure his rides looked "as good as possible" and further stated that he initially felt that Strava was not for him due to the leaderboards and competitive aspects. For users like Brian, Strava provides them with a sophisticated suite of tools to analyse their rides and pore over their data. However, there are issues that arise through Strava's inherent scripts. While users like Brian cycle more frequently, they are also subjected to not only their own surveillance but to the surveillance of their followers. Like in the quote above, users feel the need to cycle as hard as they can in order to show the best version of themselves. This links into Leary's (1996) notion of self-presentation where cyclists are seeking adulation and praise from their peers. As Craig (25) states, "It wouldn't be a recovery ride. I'd want to smash it; I'd wanna see those numbers on that screen". Changes like those experienced by Brian and Craig can lead to issues around over-training and exercise addiction.

This suggests that although digital practices lead to an increase in motivations for cycling, they can incur negative consequences; where a cyclist may have previously cycled alone, the creation of these digital artefacts shared socially transforms the experience into a social one. Though uploading rides is not ostensibly competitive in this regard, both Brian and Craig experience a "virtual form of competition" (Barratt, 2017: 328). Retrospectively looking back on their experiences, Craig noted that it had negative effects towards his health. Working full-time and training as hard as he could and as often as he could led to him over-training. Strava does little to prevent or alert users to their potential over-training. The relative effort tool offered to premium members provides users with an overview of their training load over the past seven days, though it could be clearer in how it is displayed to users. An ethical approach to helping reduce experiences of over-training or over-exertion would be to explicitly tell users that they should reduce their training load or even take a rest day.

While Brian and Craig's digital imperatives led to them experiencing social pressures to perform, others reported that their motivations to perform were heightened. Strava had become another form of social media in which they "become performers" (Schlosser, 2019: 11) to show off what they have achieved. Neil (44) stated bluntly, "You wanna show people how fast you done [it]". This again supports the ideas of self-presentation (Leary, 1996) and its heightened experiences through social media platforms (Schlosser, 2019). Strava is one platform in a suite of social media networks. Users like Neil also upload their rides and activities to other websites like Instagram. There are networks of users, profiles and hashtags that are all connected to the idealised version of a ride. Strava also offers its users the ability to share a map and statistics from their rides to other social media networks. Further encouraging users to seek attention and social rewards for their achievements.

The social surveillance from Strava can encourage users to ride more frequently and improve their health. In some cases, the social engagement of the platform can provide them with a beneficial experience. However, there are drawbacks. The digital practices and experiences of technologised engagements represents an online alternative for engaging with a community both competitively and socially that can cause issues that would not be present without it. Strava's presence and online cycling community acts as a rationale for cyclists to engage with the technology (Rivers, 2020), and in more cycling (Barratt, 2017). Sociability is further encouraged on Strava, where users can interact with each other's rides through comments and kudos that "promise inter-personal relationships" that "manifest along new, technologically mediated chains of association" (Millington 2018: 132). This was certainly the case for Eva, who explained that she already had inherent motivations for engaging in exercise, but the sociability of Strava's online community encouraged her to take part more frequently. However, others felt the need to perform more than they would have without the technology or that their motivations were to show off and portray the best version of themselves online (Schlosser, 2019).

Social surveillance comes with important policy implications. Encouraging engagement in active leisure and active transport requires a social experience for users to engage with. It is clear through this research that the social aspect of Strava provides users with an extensive network of social interactions. In some instances, Strava was their only network. This supports the work of Thiel (2016), who found that for gamification to be successful, there needs to be a social aspect. A purely rewards-based system does not elicit sustained changes to the intrinsic motivations of its users. However, there are ethical concerns around Strava's social aspect. Users like Brian and Craig experienced negative impacts on their riding as the social pressures through self-surveillance encouraged them to perform at their best on every ride. Moving forward, platforms like Strava need to consider how their scripts are interpreted by users and how their practices are changing. Barratt (2017) suggested that cyclists were at risk of over-training, and it has become apparent from this research that over-training has occurred among the respondents. Nonetheless, it can be seen that to strengthen the experiences of users, a social experience is key to the success of a gamification approach to encouraging forms of active leisure and active transport.

7.4.2 Digital imperative: the effects of self-surveillance

Strava provides cyclists with highly motivating and sophisticated tools that enable them to train effectively and monitor their performances. These scripted interactions have modified their practices to become highly reliant on these technologies. These features were explored in Chapter 6 (section 6.15.3). However, during the interviews, it became apparent that technology had resulted in negative experiences. This builds on the work of Barratt (2017: 334), who found that cyclists engaged in "highly scripted assemblage[s]" can eventually become negatively affected by Strava. It also adds to the debates outlined above (section 7.4.1), where there are implications of over-training. Respondents overall expressed enjoyment through using technology despite these negative experiences. Brian (34) experienced what he referred to as "social pressure" from the technology. Negative experiences like this had been common with users like Craig also experiencing fatigue through over-training. However, although they experienced performance anxieties and symptoms of over-training, their digital imperatives created a compulsion to record their data and continue to ride. This was predominantly down to the detailed self-surveillance and self-quantification Strava provided them. Self-surveillance rewards users like Brian and Craig with "features like graphs showing changes in exercise performance or bodily composition" (Millington, 2018: 130) but does not account for issues that can arise from consistent exposure to their own and other peoples' fitness practices. Brian and Craig were not alone in their digital imperatives resulting in negative experiences in not just their cycling but also their wider everyday lives. Borrowing from Michael (2009: 91), cyclists using Strava have become cognitively corrupted in their digital cycling practices that are "extending temptation they seem unable to resist".

Just like online social media platforms have become a significant part of people's everyday lives (Ash, Kitchin, and Leszczynski, 2019), Strava has become an integral part of the interviewee's everyday cycling practices. Strava's scripts have left individuals corrupted with a digital imperative to ride and to track. Users are exposed to a constant feed of their peers' athletic pursuits resulting in a compulsion to perform and to record. Exercise is generally considered to be part of a healthy lifestyle; however, contemporary research has shown that some individuals are at risk of exercise addiction (Baker, Griffiths, and Calado, 2021) or over-training. Both exercise addiction and over-training can have negative effects on cyclists' everyday lives, particularly on their overall health and well-being but also on their personal relationships. Cyclists like Neil (44) have experience with a compulsion to ride caused by Strava's scripts:

> "I've probably, in the last, God, it's gotta be about six or seven years. I probably haven't had a break more than four or five days from doing anything, any riding or running, or anything. And I get in the mindset of I don't wanna lose [the fitness] I've built up, you know, cause you have two weeks off, you know, people say it's hard to get it back, but so I don't wanna, you know, with injury I tried to run through an injury but, I had a bit of an injury a couple of years ago and that stopped me but I tried to, I cycled a bit more [instead]" (Neil, 44).

Neil highlights his reluctance to take time off from exercise. This reluctance exemplifies notions of exercise addiction where "an individual continues to engage in physical exercise regardless of physical injury" (Baker, Griffiths, and Calado, 2021: 2). Strava affords cyclists like Neil the ability of self-surveillance and, in this case, he is reluctant to reduce or even stop exercising through fear of losing fitness and having to train harder to reach previous fitness levels. Strava's scripts enabled Neil to see gaps in his performance and allow him to quantify where there are losses to his fitness through inconsistent or no training. In section 7.4.1, it was also apparent that Neil succumbed to social pressures experienced through Strava. The quote above, coupled with the social pressures of tracking, exemplifies how such digital imperatives can influence cyclists to ride as hard as they can rather than train in more meaningful ways. The social surveillance afforded to Neil ensured that he was consistent in uploading his rides and how his continual efforts have improved his life (Lupton, 2017). Narratives like this support current research that cyclists are more prone to exercise addiction than other sports (Torner-Quiñones *et al.,* 2019; Baker, Griffiths, and Calado, 2021). Cyclists have an idealised perception of their performances and seek to replicate them with each ride. In extreme cases their compulsions to ride come at a detriment to their physical health. Chloe (28) experienced similar compulsions to record activities:

> "I am incredibly [competitive] with myself actually, and if my graphs on Strava are missing and I've got a few weeks where that don't have anything [uploaded], I will be kicking myself for not going out and, because now I've got I'd say over 11 months or more of activity I don't wanna lose that so it definitely gives you motivation to keep yourself active."

Both Neil and Chloe experienced negative motivations from Strava. While Neil was focused on maintaining a consistent level of fitness (even through injury), Chloe was preoccupied with maintaining her digital profile. The digital profile, for Chloe, was a sign of consistency. Chloe is referring to the graph that displays weekly activities for a 12-month period. This suggests that through self-surveillance, users are subjected to compulsions to record their activities, resulting in signs of exercise addiction. These digital imperatives and compulsions support Barratt's (2017) findings whereby some of his respondents became dissatisfied with their experiences of Strava but continued to track their rides despite their negative experience. Although the experiences above depict negative aspects of using Strava, many of the respondents saw them as motivational. ‘Addiction’ was a term used by respondents in their narratives, and whilst it was at times used to describe their compulsions to exercise, it was predominantly used towards specific application scripts.

In addition to exercise addiction and over-training, research into social media and fitness inspiration (referred to as fitspiration or fitspo) have identified a risk to those engaged that can lead to exercise addiction and potential eating disorders (Raggatt *et al.,* 2018). Fitspiration is predominantly contained to social media platforms like Instagram, Facebook, and Twitter where users are exposed to images and information that portrays idealised physical traits and exercise practices (Raggatt *et al.,* 2018). Despite Strava not having all the trademarks of a fitspiration network, it does bear some resemblances; notably, many of the respondents were encouraged to maintain and increase their fitness and health overall. Much like Raggatt *et al.,* (2018) found many of the respondents reported positive benefits to tracking their rides through Strava citing increased motivations and social interactions. Therefore, it is important to consider the potential risks that have been experienced by some respondents. Fitspiration draws attention to idealised male and female bodies “that are slim, physically fit and well-groomed, performing dominant notions of sexual attractiveness” (Lupton, 2016a: 2).

Like Lupton (2016a) states, cyclists are also exposed to idealised images of body weight and composition with leanness and low body weight “considered advantageous for performance” (Schofield, Thorpe, and Sims, 2020: 9). Images of slender, vascular professional cyclists are commonly seen in the media – particularly images of those who have just won a hard stage of a race like the Tour de France (Figure 7.1). Along with this power to weight ratios are also reported frequently whereby a cyclist’s average power is divided by their weight. For example, a 70-kilogram cyclist able to sustain an average power of 300 watts would have a power-to-weight ratio of 4.3 watts per kilogram (often expressed as 4.3w/kg). Although research suggests that there is a risk of developing eating disorders through excessive exercise (Baker, Griffiths, and Calado, 2021), a focus on fitspiration (Raggatt *et al.,* 2018), and self-surveillance showed that many of the respondents reported few changes to their diet overall. However, several respondents report that they still eat “rubbish” (Charlie, 26), or they can “eat what I want” (Ryan, 51), or they “exercise so we can have a poor diet” (Brian, 34).

Figure 7.1 Pawel Poljanski's legs after a stage of the Tour de France 2017 (Wynn, 2017) Image Credit: Yuzuru Sunada.

Despite research suggesting that exercise addiction (Baker, Griffiths, and Calado, 2021) and idealised body representation on social media (Raggatt *et al.,* 2018) are considered to effect the eating habits of endurance athletes (Schofield, Thorpe, and Sims, 2020), particularly female athletes (Koppenburg *et al.,* 2022) this was not representative of the respondents. Respondents, particularly females, considered themselves to have “always eaten pretty healthily” (Chloe, 28) and be “quite confident with nutrition” (Olivia, 37). Out of the respondents, two reported the use of dieting to reduce their weight. One respondent, Jack (60), had considered the effect of his diet to help him lose weight. Jack was conscious of diet because of his cycling as he stated that he “like[s] food” and that cycling enabled him to eat more though he wanted to improve and so turned to his diet as a result. While Jack aimed to improve his diet, Jacob (22) considered dieting during specific times of the year or for specific events:

> "I just started trying to eat better and think about my weight. Whereas recently it was just, it was like a certain thing, but I now see a bit more of a fluctuation, a wider fluctuation, and so it's sort of, I know if I'm coming down to a, if I need to be light for a specific time of year, I will plan around that now. It's only happened in the last sort of two years where I sort of start to be on a bit of a diet to either lose a little bit of weight just to get down ready for going to the Alps or something like that…" (Jacob, 22).

Out of all the respondents Jacob was the only person to actively consider weight for specific events. The quote above emphasises the ideals of leanness and low body weight (Schofield, Thorpe, and Sims, 2020) that are often attributed to better performance in cycling particularly up mountains like the Alps. Although Jacob has actively dieted to reduce his weight for specific events, he also stated that during heavy periods of training, he eats a lot more and feels he "can get away with eating more junk". From the responses to this research there is little support for cyclists experiencing increased risk to eating disorders through their use of technology. However, this was not a primary focus of the research and as such, more research is needed to identify what effects, if any, technologised practices of cyclists affect their diets.

Despite the potential negative effects of Strava outlined above, the scripts themselves are not designed to have negative implications towards users' health. Respondents to this research, and users in general, voluntarily opt into using Strava to share their recorded data and engage in self-surveillance as well as social surveillance. The data users receive from Strava can provide them with rich and detailed information that they can seek meaning from (Lupton, 2017) and, in some instances, seek medical advice (section 6.17). While there are negative outcomes from social surveillance, overall, 28 of the respondents reported positive experiences of using Strava and GPS devices.

This supports Lupton (2017: 12), who states users "can gain much pleasure from their participation in social surveillance, enjoying feeling part of a community of like-minded people". This was shared by users like Eva (59), who used Strava as her means of social interaction with fellow cyclists. However, moving forward, there are some scripts that can be interpreted beyond their intended meaning. Coupled with growing trends of fitspiration on other social media platforms, Strava and other applications offering self-surveillance must consider how their scripts are used and the life cycles of their use. These digital imperatives can cause users to experience compulsions to not only track their data but exercise to the detriment of their own health and even relationships.

7.4.3 Digital imperative: familial disparities

During analysis, it was evident that increased motivations equated to increased fitness levels amongst respondents. However, as explored above there were also some negative consequences that occurred through self and social surveillance. The ability to track and quantify performances, compete on segments, and complete challenges (scripts actively designed to encourage more cycling) can have an adverse effect on cyclists' wider everyday lives. This has been particularly notable in those interviewees with familial, household, or relationship commitments. As noted by Baker, Griffiths, and Calado (2021), another side effect of exercise addiction is defined as having a detrimental impact on personal relationships. While increased motivations and subsequent increases in cycling was seen as a positive aspect for respondents, it resulted in conflict within their home dynamic for others. Debbie (44) explains the implications it meant for her in the exchange below:

> **Interviewer:** "Have you experienced any issues in your home life due to time spent cycling?"
> **Debbie:** "Yes, I've actually got divorced because of it."
> **Interviewer:** "Crikey."

Debbie: "Yes, yeah so I think my, I'm probably wanting to do between 10 and 12 hours a week cycling and, yeah that did cause a marriage breakdown."

Interviewer: "I'm sorry to hear that."

Debbie: "That's alright it's fine."

Interviewer: "Was your partner active at all?"

Debbie: "No, not really, so I think he played cricket on a Saturday, but that was pretty much it, so he never really got why I was into so much. And especially when it changed from sort of ***riding my bike to training on a bike*** [emphasis added]. I think that became very much more focused I think he found that very hard. And there was training camps in Majorca and cycling in the Alps and all that type of stuff, and he found that incredibly hard."

The example from Debbie above is an extreme representation of familial conflict because of time spent cycling. Debbie was recruited into digital cycling practices as she started cycling (section 6.11.1), and initially, she used the technology while not fully "understanding it" (Debbie, 44). Since then, she has become subsumed by the technology and is fully immersed within the technologised practices as well as physical cycling practices. This is seen above, where she describes transitioning from "riding my bike to training on a bike". The shift from riding to training denotes that Debbie's self-surveillance practices have become focused on recording her data to facilitate improvements (Lupton, 2017) in her cycling and overall fitness. These improvements, however, came at a cost. Nomaguchi and Bianchi (2004) found married women spend an average of four hours exercising per two-week period. Debbie was cycling three times that amount in one week on top of her other daily and familial commitments. However, she was not the only cyclist interviewed to experience familial conflicts due to time spent cycling. Olivia (37) reported that "relationships haven't particularly lasted if there's a massive gap between sporting levels". Both Debbie and Olivia identified what would be needed for relationships to be successful in the future: Debbie spoke about finding a "better balance", whereas Olivia continued that cycling and other forms of exercise are an important part of her lifestyle and "if they don't like that side of things that's kind of who I am so probably not suited to each other".

The examples from Debbie and Olivia were extreme and not wholly representative of the research sample. They do, however, display disparities that further exacerbate the gendered nature of cycling. As Nomaguchi and Bianchi (2004) highlighted the gendered nature of exercise time - noting that men exercised more than women a sentiment that was furthered with the responses given by male interviewees. Men stated they aimed to cycle on average four or more times a week; in contrast, women aimed for three times per week. Debbie and Olivia were an exception to this with comparable exercise times to male respondents. It is not just time allocated to exercise that was gendered in responses; experiences of familial conflict were also gendered in its severity. Where the examples above display the breakdown of personal relationships this was not the same for men. When discussing these conflicts with male respondents, they reported that they reduced any tensions with their partners by keeping them informed and fitting it in around other commitments.

Despite keeping their partners informed, they still reported friction. However, these experiences did not result in the complete breakdown of a relationship. As Greg (57) recalls:

> "I'm going back to running, and because that's run every day, it did cause a bit of friction, but my wife realised it's just for the month and put up with it. But yeah, I think we're lucky we both appreciate, we both have our own things to do […] I think I've got to keep things in control so as not to cross any boundaries" (Greg, 57).

Greg referred to a personal challenge he set himself to run every day for a month. Although there was some initial tension from his wife, she was accepting of his increased time exercising. Greg continued that:

> “it’s a constant discussion about yeah, ‘I want to do a ride on Sunday, it’s gonna take six hours, is that feasible? When’s the best time for me to start? Or should I cancel it?’ yeah, it’s a constant discussion” (Greg, 57).

Greg’s response highlights the fact that experienced cyclists can regularly spend three or more hours on a single bike ride. He was conscious that this could eat into time otherwise meant for familial responsibilities or commitments. It is clear from this research that Strava can encourage cyclists to cycle more frequently, which can come at the detriment to their familial commitments. This supports the findings of Barratt (2017), whose research highlighted cyclists participating in the Rapha Festive 500 challenge on Strava (a challenge that sees cyclists ride a cumulative distance of 500 kilometres between Christmas and New Year) reported tensions in their household. He also noted that during this period cyclists often had more free time due to time off from work, however, this did not necessarily equate to more time for cycling due to cultural practices associated with the holiday season. Although Barratt (2017) theorised that Strava challenges were potential culprits for encouraging cyclists to shirk their household responsibilities, this research suggests that it is Strava as a whole that encourages cyclists to cycle more frequently and is responsible for changing their motivations.

It is also clear that there are inequalities experienced by respondents to their increased cycling motivations. There are issues surrounding the gendered experiences of respondents and the effects they had on their family and home dynamics. It is clear the findings support those of Barratt (2017), but there is more to be done to address the gendered experiences of cyclists. These gender disparities are not just found within cycling but are endemic in sport participation as a whole (see Wellard, 2006; Costello, Bieuzen, and Bleakley, 2014; Cowley *et al.,* 2021). More research is needed to further understand the effects of technologised practices particularly on familial commitments. This is of importance to ensure that there are equal opportunities afforded to both men and women and to ensure women’s engagement is not further disadvantaged. Gender disparity is discussed further in section 7.5.

7.5 Gendered cycling

In the UK, cycling is a gendered pursuit with much greater participation by men than women (Section 5.3). Campaigns to encourage women to participate in sport, like Sport England's 'This Girl Can' launched in 2015, encourages and celebrates women taking part in physical activities and exercise despite their abilities or how they look (This Girl Can, 2022) or Women in Sport's #TimeTogether launched in 2021 where mothers and daughters are encouraged to spend time together being active during October. Exercise is inherently gendered and is reflected by the media and even in contemporary research. Men are found to be more active than women (The Lancet Public Health, 2019), men also outnumber women as participants in sports and exercise research (Costell, Bieuzen, and Bleakley, 2014), and the type of exercise conducted has also been found to be gendered (Wiley, Shaw, and Havitz, 2010). There is a clear precedent that participation within sport overall is gendered. This can be seen through the participation of cycling, with 71% male and 29% female participation (ONS, 2019). There is also a wealth of research into the gendered nature of cycling along with its lack of diversity (see Pooley *et al.,* 2011; Goldbuff and Aldred, 2012; Aldred, 2013; Aldred and Jungnickel, 2014; Davidson, 2021).

The sample selection for this research was representative of the gender participation of cyclists within the UK. Although the main concern of the research was not to understand the differences in gender participation, it did identify gendered trends from the responses. Strava is no exception to gendered relations, and "critical consideration is needed around the gendered implications associated with gamified fitness tracking apps" (Barratt, 2017: 334). Strava's scripts are inherently masculine. This builds on the work of Wellard's (2002) idea of sporting masculinity (competitiveness and aggression) that remain largely unchallenged. Strava's segment features are a typical example of sporting masculinity, with its digital leaderboards encouraging active competition among its users. However, while it typifies traits of Wellard's (2002) sporting masculinity, responses from participants were not congruent with these traditional understandings. Segments often affect the motivations of the respondents (section 6.15.1); however, the participants actively being competitive and seeking first place on the leaderboards were predominantly women. While Barratt (2017) argued that gamified applications like Strava will further widen the gender disparity this research found that male respondents were more readily self-competitive rather than outwardly competitive in the traditional understandings of sporting masculinity. Conversely, women spoke more openly about targeting and competing for the Queen of the Mountains title and of how they were “addicted” (Sophia, 40) and “thrive off that level of challenge” (Jess, 36).

Male participants were not absent in actively competing for King of the Mountains challenges. Their responses alluded to notions of the self – comparison, competition, quantification, and surveillance – they were more insular in their focus. Often citing a desire to see personal bests on their rides as opposed to trophies or crowns associated with placing highly on the leaderboards. While there is no doubt that gamification effects the practices of cyclists, the relationship cyclists have with these application scripts and particular aspects of them (co)evolve over time. This is evident with the case of segments and Barratt’s (2017) research, where he found men to be predominantly participating with and competing in such challenges. Strava’s competitive landscape has remained largely unchanged since its inception in 2009. Segregated leaderboards (male and female) and gendered first place descriptors (King or Queen of the Mountain) could continue to “reinscribe conventional gender binaries” (Barrie, Waitt, and Brennan-Horley, 2019: 2). The practices of cyclists, both male and female are in a constant state of (co)evolution and applications along with research must consider the gendered implications of gamification to prevent furthering disparities in women’s fitness.

An explanation for male respondents not being as actively competitive with Strava’s segments could be to do with saturation of competition. It is already evident that men are representative of 70% of cyclists in the UK, and as a result, the level of competition has become harder in the years since Strava’s release. This has resulted in Strava releasing new leaderboards for segments in order to increase participation and competitiveness. One such addition is the Strava local legend feature, where users are rewarded a title for their persistence (a wreath is awarded to the user with the most rides over a rolling 90 days). This shows that Strava changes the scripts to keep users actively engaged. Despite female respondents reporting that they regularly competed for Queen of the Mountains and took part in Strava's inherently masculine scripts, it must not be assumed that this type of gamification is not gendered. Respondents to this research – and other research surrounding Strava and participation – are engaging with the already engaged. That is, female respondents are already actively cycling in an already gendered pursuit, actively using Strava, and actively engaged with the platform. In this regard, the average Strava user can be considered to fall into Perez's (2020) notion of *'the default male'.* In her book *Invisible Women,* Perez (2020: 25) states that "[f]or too long we have positioned women as a deviation from standard humanity".

Strava's social experience was also popular amongst female respondents. With users like Eva (59), for whom Strava provided their cycling social network. Similarly, users like Sophia (40) actively liked to engage with others through virtual kudos and comments on their activities. However, Sophia's experience was not always positive. She recalled a heated online discussion where a male member of her cycling club belittled her achievement of completing a chain-gang (Section 2.3.3) by titling his ride "as if it was the easiest thing he's ever done" (Sophia, 40). This is further perpetuated in virtual cycling platforms like Zwift, where Reed *et al.* (2022: 9) noted that the online chat functionality fostered "sexist and inappropriate language" towards women. Reed *et al.* (2022) also found that purely virtual platforms like Zwift were able to alleviate dangers women often associated with cycling outside, but it fell short of providing them with a fair gender experience, instead perpetuating the default male stereotype (Perez, 2020).

Although the research identified female respondents participated more frequently in the gamified features and scripts of Strava section 7.4.3 identified the gender disparity of time spent exercising and participating in sport.

Nomaguchi and Bianchi’s (2004) research found that married men exercise on average 47 minutes more per two-week period than women. Their findings show that men are afforded more time within their familial commitments to pursue exercise. This supports the gender bias that men experience more free time within their daily schedules. Perez (2020) notes that men spend less time with caring duties such as childcare and housework. Thus, men have more free time to spend on leisure pursuits like cycling. It was evident that male respondents were seeking out time from their home schedules to cycle, run, or take part in other activities. Neil (44) had planned family holidays around sporting competitions, which had resulted in some conflict with his spouse. Oliver (47) also reported that during holidays abroad, he would still cycle frequently and cited that to avoid conflict, he would rise early while his partner was still asleep. Of the male respondents, there were few that had experienced any significant conflict due to their time cycling; however, for Debbie (44) and Olivia (37), their commitments to cycling resulted in more severe impacts on their relationships.

Janzen and Cousins (1995: 67) found that married women “shed their independence” and share the leisure practices of their spouses. This is supported by the experiences of both Debbie and Olivia where their relationships with inactive partners resulted in a breakdown due to the difference in activity levels. While they maintained their exercise independence, they experienced more severe consequences than their male counterparts. More recently, Palmer and Leberman (2009) looked at the multiple identities of Elite athletes as mothers, and they acknowledged that continued participation in elite-level sports challenged gender norms. Despite continued participation, they also reported that women still expressed guilt, particularly surrounding the goals of their children and partners. They concluded that while challenging gender norms through their continued participation, their verbalisation of guilt continued to reinforce them. This shows that there are still barriers to equal opportunities for women and sport and the responses from Debbie and Olivia further identify such gender inequalities.

Gender disparity was not a prominent purpose of this research; however, during the analysis of the data, it was evident that there were differences between the respondents. Due to this, it has been pertinent to acknowledge these differences. Applications like Strava perpetuate sporting masculinity stereotypes through segments and challenges. This research showed that male participants were more likely to compete against themselves rather than the leaderboards, whereas female participants actively competed in the Queen of the Mountains and admitted to targeting specific segments more frequently than men. However, this could be because cycling is a gendered sport, and therefore, men's leaderboards are more heavily contested than women's leaderboards. Along with this, women reported more severe repercussions for participating in high levels of cycling. This supports the work of Janzen and Cousins (1995), who found that women's leisure practices often imitated their spouses as well as fulfilling gender norms of home life. More recently, research by Palmer and Leberman (2009) found that women can maintain participation in elite athleticism, but this is often afforded to them through extensive networks of support.

As previously mentioned, much of the findings of this research are based on the experiences of already engaged female cyclists. In order for Strava and other fitness applications to ensure that gender disparity is not increased, more needs to be done to identify forms of gamification and sociability that encourage the participation of women. Cycling is already gendered, and statistics released from Strava show that although many of its female users engage with it for their leisure practices, they are still 12% less likely to cycle on their commute than their male counterparts (Delves, 2019). Strava boasts it has a community of over 100 million athletes worldwide engaged with the platform (Strava, 2022b) and claims that 17% of the UK population use Strava (Hughes, 2021). Although it is not clear how accurate that percentage is, regardless, Strava has a large user base within the UK and worldwide. Moving forward consideration of the needs of women must be accounted for. This also extends to initiatives that seek to engage users in other forms of active leisure and transport. As Theil (2016) states, successful implementations of gamification require more than just extrinsic motivators, and sociability is just as important for eliciting long-term changes in practices.

Much like Perez (2020: XII) writes in her book, women are not represented in a world that is "increasingly reliant on and in thrall to data" Perez is referring to what she calls the '*gender data gap'*. This is pertinent to the development of health technologies and applications, as women are not seen as consumers in a male-dominated market. Despite the ability to remove barriers to participation, Reed *et al.* (2022: 7) noted that the virtual cycling platform Zwift "has reproduced the deep-rooted male gaze". This has also been evident by participants in this research who had uncomfortable experiences online. Sophia (40), who experienced male aggression online, and Olivia (37), who received unsolicited contact through Strava's Fly-by feature that could be considered stalking. Strava, Zwift, and other applications are currently based around sporting masculinity practices that women engage in. Further research is needed to fully understand how applications like Strava can impact the leisure practices of female participants and ensure that as the practices (co)evolve, they do not widen these gender disparities.

7.6 Encouraging active leisure and travel

The data presented in the empirical chapter and above show the mechanisms by which applications such as Strava motivate frequency and duration of activity. Findings such as these could be used to inform new ways of harnessing the potential of applications for health and environmental purposes. However, caution must be taken as this research is undertaken on those who are already 'active' and so the application scripts and users' practices have (co)evolved over time. It is evident that Strava has managed to retain a large user base and gained many more users during the COVID-19 pandemic and subsequent lockdowns - reporting a 33% increase in uploaded activities (Mackinnon, 2020). While many of these users turned to Strava in the wake of gyms and other leisure facilities closing; what can be done to further retain and encourage others to engage with outdoor active leisure and transport practices?

This research found that those actively engaged with Strava have found its graphical user interface to be highly motivating in encouraging and facilitating more regular cycling. As Krish (40) says, “If you can measure it, you can manage it”. Krish was referring to Strava’s ability for users to set weekly, monthly, and/or yearly targets. Self-surveillance and self-quantification are important in users being able to inscribe meanings to their personal information (Lupton, 2017). While self-surveillance plays an important role within encouraging change, Lupton (2017: 8) also notes the importance sociability plays in increasing motivations and how they are important “in designing interventions for behavioural change related to health”. This research supports the findings of Lupton (2017) and Thiel (2016) that online social aspects of applications like Strava are an important part of facilitating long-term changes, particularly within cyclists' practices. Social aspects were particularly key for female participants who valued the ability to communicate with and keep up to date with their active network of friends. Strava allowed users like Chloe (28) to know how friends and family are and “if they’re ok” due to uploading activities.

Strava has replaced the “overt and broader meaning of social fitness” (Lupton, 2017: 8) with users able to share and upload their fitness data online. Along with this, it also changed the physical practices of cyclists whose competition switched to Strava’s digital online leaderboards rather than physical markers, such as village signs while out on their bikes (Dansie, 2013). This is mirrored by respondents like Aaron (53) and his friends, where post-ride Strava analysis has become part of their routines:

> “[Strava is] part of the fun, isn’t it? So, yeah that’s definitely, if we didn’t know how fast we’d done what segments we’d done particularly well on, who’s on what leaderboard […] then, arguably, it wouldn’t be so much fun” (Aaron, 53).

Moving forward, health applications should seek to replicate the experiences of users like Aaron with the integration of social surveillance that not only encourages users to be more active but also enhances their enjoyment.

However, the dangers of social surveillance and the potential for encouraging exercise addiction must also be considered. There is also potential for encouraging dangerous behaviour, although it is not built into the app, it is there, nevertheless. In 2012, Strava faced a lawsuit over the death of a cyclist who attempted to take back their King of the Mountain title on a downhill segment they had lost (MacMichael, 2012; Hill, 2012). In response, Strava now allows users to flag segments that are potentially hazardous. As Yen, Mulley, and Burke (2018) conclude, careful consideration must be taken to ensure that there is a positive outcome and though Strava provides social interaction, its inherently masculine design of competition can encourage users to take unnecessary risks. Strava did, however, encourage users to seek more ways in which they could use their bikes for active transport.

In 2016, Strava launched the #COMMUTESCOUNT (commutes count) in an attempt to increase participation in cycle commuting on the global bike to work day (10^{th} May). In a blog post, they stated that cycle commuting accounts for more than 50% of cycling activities uploaded each week to Strava (Vontz, 2016). Commuting and cycling for utility was something many participants regularly took part in, with it being the predominant mode of transport and leisure practice for some. During the interviews, respondents were asked whether they had considered replacing car journeys due to their increased use of technology and increased motivations for cycling. For some, their intentions to travel by bike had increased, with them actively considering which journeys they could replace with cycling. This is of contemporary importance due to the health benefits associated with forms of active travel (see Hendriksen *et al.,* 2010; Burgess, 2013; O'Hern and Oxley, 2015).

Contemporary research has also been conducted into the use of gamification in encouraging participation in active transport. Coombes and Jones (2016) examined an initiative to encourage active travel in school children during their school commute. While their findings found that gamification can lead to an increase in participation, the study was limited, and overall, they concluded that engagement with the initiative was low. To initiate meaningful change, gamification needs to acquire relevant associated meanings for participants to fully recruit it into their practices. Shove, Pantzar, and Watson (2012) note that practices are made of the linking of elements – materials, competencies, and meanings (section 4.3) – participants in Coombes and Jones' study had the relevant materials and competencies but lacked the development of relevant meanings for the practice to continue resulting in the death of the practice. The practices of participants within this research have (co)developed and (co)evolved with their use of technology. They have developed meanings and associations of self-quantification and self-surveillance that have become more entrenched in their practices, and their cycling has become contingent on these digitally mediated practices.

Participants have experienced changes in their practices through their use of digital cycling applications like Strava, which have led to an increase in personal biometric monitoring and self-surveillance. As Barratt (2017) found, technology like Strava has the ability to increase respondents' intrinsic motivations (health and performance monitoring and self-quantification) through extrinsic motivators (gamification and competition such as segments and challenges). Many of the respondents reported they had experienced changes in their practices over time, which led to their motivations towards cycling changing. This resulted in increasing their use of technology and associated the technology with tracking improvements in their overall health and fitness (Section 6.15.3, 6.16), as well as a catalogue of their past experiences (Section 6.14). Their intrinsic motivations to exercise were supplemented through extrinsic motivations associated with Strava and self-surveillance. Yen, Mulley, and Burke (2018) noted that gamification that utilises leaderboards and challenges as extrinsic motivators can result in longer-term effects on intrinsic motivation as opposed to monetary incentives.

Technology was perceived by respondents to positively impact their riding overall. Self-quantification and the ability for users to perceive changes in their overall fitness levels was often cited as a motivating factor. In turn, this leads to an increase in their intrinsic motivations. However, the caveat being participants were already cyclists and already had some level of inherent motivation that encouraged them to take part in cycling. Many of the respondents had access to other forms of private transport, like cars. This is important to understand as those with access to a car are less likely to travel to work by bike, as Tortosa *et al.* (2021) found. Their paper found that despite the availability of bicycle infrastructure, it did not equate to an increase in active transport along with this they found the majority of trips for utility purposes were conducted by socio-economically disadvantaged populations. While bicycle infrastructure improvement will help to reduce barriers to cycling, particularly safety (Aldred, 2016; Hong, McArthur, and Livingston, 2021), simply building infrastructure is not enough to encourage more active engagement. Respondents like Jess (36) were reluctant to cycle more regularly due to the lack of safe storage places to leave her bike. Those that commuted or cycled regularly for utility purposes often reported having a different bike for this specific purpose.

Although applications like Strava and Strava metro can help to inform planning decisions for the implementation of cycling infrastructure there are issues around the data collected. As noted in section 7.5, female cyclists were 12% less likely to commute by bike than male cyclists (Delves, 2019). In an already gendered sport, this highlights the significance of the *'gender data gap'* (Perez, 2020). The habits and commutes of women are different to those of men. Women often fall into the roles of carers, and their daily commutes consist of "several small interconnected trips" that are referred to as "'trip-chaining'" (Perez, 2020: 30). Aldred *et al*. (2017) noted that it is important to understand how changes and the implementation of new infrastructure will affect the trips of carers which are predominantly women.

Hong, McArthur, and Livingston (2021) used Strava to evaluate newly implemented infrastructure in Glasgow city centre. Although they reported short-term success in its implementation using Strava to evaluate its effectiveness, Strava is not representative of whether infrastructure has encouraged those that did not already cycle to cycle. Also, as Tortosa *et al.* (2021) found, city centre cycling infrastructure fulfils the needs of local residents but does not encourage those that are more socio-economically privileged and live outside the city centre to commute by bike. As shown from this research, change to practices is possible using gamification, but the level of change is dependent on the length of time users are subjected to it. Strava has been around since 2009, and while not all the respondents have been using it for that long, many of them have been members for several years. The success of Strava for increasing intrinsic motivations can also be attributed to its online sociability providing users with a sense of connectedness to like-minded individuals.

The success of Strava in becoming embedded within cyclists' digital practices show that it is successful in implementing sustained routine changes and increased intrinsic motivations. While Strava provides cyclists (and other athletes) an online social network to share their rides and compete with others, it also aggregates users' data into a package called Strava Metro for local governments. Strava Metro aims to use this aggregated information to inform new cycling infrastructure by identifying where cyclists cycle. Much like the commutes count campaign in 2016, users can mark their rides as commutes, which can, in turn, be filtered through Strava Metro, allowing identification between leisure and utilitarian trips. Yen, Mulley, and Burke (2018) noted that local authorities will inevitably need to "invest in gamified approaches" to ensure they are effective in the long term. It is clear from this research that applications like Strava are effective in increasing change. Their implementation of segments and challenges have been shown to increase the intrinsic motivations of users, and as a result, it is important to understand these lifecycles to ensure effective implementation of future transport and health initiatives.

7.7 Digital creep and the routinisation of digital leisure

Discussing digital habits within this research has made it apparent that digital practices extend beyond the realm of cycling. Many of the respondents were forthcoming with their narratives of digital creep. Life is increasingly mediated through technology (Ash, Kitchin, and Leszczynski, 2019), particularly with smartphone use becoming ubiquitous in society (Hitcham, Jackson, and James, 2023). In the relatively short time that smartphones have been available, they have permeated into all aspects of daily life (Leszczynski, 2019). Cyclists have proved to be a pertinent case study in assessing the prevalence and permeation of technology within their practices. There is a rich history of technology and quantification in cycling (see Chapter 3), and as such, cyclists have been particularly proactive in the uptake of new forms of technology (Barratt, 2017). Many of the respondents had previously used technology to quantify their rides, such as mile-o-meters and non-smart bike computers. The advent of the smartphone and, in turn, GPS tracking applications added a new dimension to their ability to track and quantify their rides. The exploration of cyclists' use of technology in Chapter 6 found that through using smartphone applications, they increasingly sought more data or the ability to see real-time information during their rides.

The thesis calls this increasing permeation of digital technology in all aspects of life *digital creep*. For the respondents, the digital creep was shown by their increasing need for more data to track more information, whether that be during their rides with the ability to see real-time information (section 6.11.3) or to track their daily activities. As the empirical research has shown, participants started their digital journeys through the use of GPS-enabled smartphone applications before moving onto dedicated GPS devices such as bike computers, this then led to respondents seeking more detailed information about their bodily performances (section 6.17). However, digital creep is not unique to cyclists. Screen time and smartphone addiction are relatively new areas of concern for research (Hitcham, Jackson, and James, 2023). The use of digital devices is increasing in all areas of everyday life.

Through this research, it has become evident that digital technologies have become embedded into the routines and habits of cyclists. Digital imperatives highlighted that technology had crept into the participant's practices, and they had a compulsion to track their rides and record data regardless of whether they actively used it. It has been particularly evident through the empirical chapter that self-quantification has been a long-standing practice among cyclists' pre-digital technology. Cyclists used non-smart technology to quantify their rides and analyse the time and distances they spent cycling. This long history of cyclists and self-quantification meant they were acutely aware of the technology usage and able to clearly articulate their experiences and provide rich narratives about their habits and practices. These narratives highlighted examples of digital creep and that practices had become contingent on digital technology like Chloe (28), who reported that “if my watch hasn’t got battery, I don’t go”. This sentiment was also expressed by other users like Jacob (22), who “will wait for it [device] to charge, then I’ll go out”. Narratives like this highlight how integral digital technology has become to cyclists despite the fact that cycling is not reliant on technology to take place. Cycling takes place in a coded space. Kitchin and Dodge (2011) define coded space as “software [that] makes a difference to the transduction of spatiality, but the relationship between code and space is not mutually constituted”. In this regard, cycling can still take place without the technology present, but the experiences of cyclists are diminished without it.

The empirical chapter started by highlighting how the meaning of cycling had changed over time. Cyclists initially associated cycling with meanings of independence (section 6.4), utility (section 6.5), health and fitness (6.6), and quantification (6.7). This fluid nature of meanings meant that the practices of cyclists were able to (co)evolve through the different lifecycles and stages of the cyclists’ lives. For Shove, Pantzar, and Watson (2012), the meanings within practices can change as new technologies are developed. Practices that were once considered to be normal are, with the development of new technologies, considered unusual. However, elements of practices like materials and competencies can be considered “relatively stable” (Shove, Pantzar, and Watson, 2012: 59), while meanings can be considered unstable. The fluid nature of meanings has been prevalent throughout the narratives of the cyclists interviewed. Much like the development of Nordic walking, meanings associated with walking with sticks were once associated with ideas of frailty, and old age became replaced by notions of nature and improved fitness (Shove and Pantzar, 2005). Meanings associated with cycling have been (co)developed with technology throughout cyclists’ lives.

As cyclists had already been receptive to forms of non-smart technology (section 6.10), allowing them to quantify their cycling more than just riding for a certain period of time, cyclists associated the information with more informed training. With the development of technology and the incorporation of applications like Strava, cyclists had a greater ability to relive their rides through the production of digital artefacts. While non-smart technology allowed cyclists to quantify their rides, it was hard to gain rich insight or meaning from it (Lupton, 2017). The use of digital technologies allowed cyclists to gain rich insights from their socio-technical assemblages and identify changes and patterns within their health and fitness (Lupton, 2017). Further to this, digital technologies had already begun to (re)shape wider everyday life through increasingly mediated interactions. This history of self-quantification meant that cyclists had been susceptible to digital creep.

Smartphones were already being increasingly used when Strava was released in 2009. Smartphone technology had already begun to creep into daily life; being used for navigation and directing patterns of consumption meant that spatial interactions were already being (co)produced through digital interactions (Leszczynski, 2019). The shared competencies of using smartphones coupled with the graphical presentation of data through applications like Strava allowed for the transfer of relevant knowledge and competencies (Shove, Pantzar, and Watson, 2012) into the practices of cycling. Shove, Pantzar, and Watson (2012) report that the development of new materials leads to the emergence of new practices and the subsequent death of old practices. In this case, smartphones, the emergence of Strava and the proliferation of dedicated GPS devices led to the development of new digital cycling practices but ushered in the death of cycling with and using non-smart technology. Previous quantification of distances, times, and average speeds (Till, 2014) was replaced by applications that provided more in-depth visual analysis and a platform to compete against their peers (Barratt, 2017).

It became apparent from respondents that digital creep was prevalent in their wider everyday lives, that have become mediated through technology, and that cycling was no different. The quotes from Chloe (28) and Jacob (22) at the beginning of this section highlight how integral this technology has become in their practices. The gamified scripts of Strava have played an important role in technology and have become an integral part in their practices. Participants highlighted how the use of segments (Section 6.15.1) and challenges (Section 6.15.2) altered their motivations for cycling. Extrinsic motivations like segments and challenges rewarded users with digital trophies on their rides. Respondents reported they actively sought to receive trophies on their rides and, at times, pushed harder or rode more because of this. The use of applications and Strava had become part of their practices where cyclists referred to the analysis of post-ride Strava, where they examined their achievements and quantified their performances. This was evident in responses like Aaron (53) in section 7.6, where comparing his efforts against his friends became part of the fun of cycling.

Strava has become entrenched within the cycling habits of the respondents. Borrowing from Michael (2000: 3), it had been apparent that these digital GPS devices and applications had become “mundane technologies”. Section 6.18 explored the routines of cyclists and saw that technology was compared to other mundane technologies like “kettles” (Ryan, 51) and “helmets” (Bill, 61). The novelty of the technology had become an expectant part of their practices. Just as Shove and Southerton (2000) found that fridge freezers led to the development of new practices within daily routines, the associated practices of cycling had been changed through the incorporation of digital technology. Digital imperatives of self-surveillance and self-quantification have become embedded into their cycling practices.

Moreover, the (re)classification of digital technology into the mundane highlights how technology has crept into all aspects of daily life and transitioned into an integral part of the socio-technical assemblage. Mobile health applications, self-surveillance, and self-quantification are receiving increasing levels of interest from employers and health insurance companies (Till, 2014; Lupton, 2017). Employers are encouraging employees to lead more active and healthy lifestyles to reduce absences due to illness, and health insurance premiums (particularly in the USA) are being calculated through self-surveillance devices (Lupton, 2017). As Till (2014: 451) writes, “with the use of digital self-tracking devices, we are currently witnessing the transformation of individual health activities into quantified forms ripe for the extraction of value". Till (2014: 458), along with Lupton (2017), highlights how individuals' self-surveillance is increasingly becoming important to corporations and businesses to produce a more effective and functional workforce and the "potential commercialization of the exercising bodies".

As section 7.6 explored, digital technologies have the ability to encourage users to take part in active leisure and transport more frequently. This has been achieved by the intensified experiences through applications like Strava. The findings of this research also present the successful applications of gamification in a social network that has become popular amongst an active cycling community. Contemporary research like that of Coombes and Jones (2016) highlighted that future schemes using gamification must be present for extended periods of time in order for long-term habits of active travel to take place. Furthermore, the understanding of the habits formed by cyclists in this research can be applied to wider daily life. Much like the run-commuters of Cook's (2021) research, the cyclists interviewed also had already established cycling practices. The research also found that these established technologised practices increased the motivations of cyclists, which in turn led to users seeking more ways to ride more frequently. This resulted in the use of cycling for commuting.

While Cook (2021) notes that data from Strava represents the already engaged, identifying changes to the technologised practices of those participating in active leisure pursuits can inform future initiatives in the pursuit of active leisure and transport. Examining the narratives of digital creep evident from the participants of this research has highlighted how prevalent technology has become in the pursuit of cycling. However, many of the respondents' use of technology goes beyond cycling and permeates into other aspects of their lives. Practice theory has identified that the meanings associated with Strava encourage users to become more active. Gamified scripts, along with self and social surveillance from applications like Strava, are also integral to users becoming more motivated. Thiel (2016) noted the importance of social integration and gamification in long-term change to motivation and practices. The narratives of digital creep explored within this thesis have identified how technology has become routinised within daily practices. As such, socio-technical practices should be considered when exploring active transport and leisure routines.

7.8 Summary

This chapter has explored technology's wider roles within the lives of cyclists and the impacts digitally-mediated practices can have upon them. Technology has been responsible for increasing users' understanding of their own abilities and allowed them to quantify their own performances through an array of metrics. Over time, cyclists' practices have become contingent on and (co)evolved with the technology. However, these digitally mediated practices can result in cyclists becoming "cognitively corrupted" (Michael, 2009: 91). Through their cycling practices and varied engagements with technology, cyclists' motivations are (re)shaped and amidst this (re)shaping their practices can also create negative effects outside of their cycling.

Strava can replace the social aspects of cycling clubs and group rides by providing users with online camaraderie. For those cyclists that are not members of a club or that do most of their cycling alone, Strava has become their community. The community experience provided by Strava has also become a motivating factor driving users to cycle more frequently. Their motivations are increased due to sociability (Chen and Pang, 2012) and the adulation (Leary, 1996) they receive from their peers for uploading their rides. Respondents understood that their motivations were increased because of these social aspects and stated that without Strava, they would cycle less frequently. However, at times, the social aspects could result in performance anxiety, where cyclists felt they needed to try their hardest on each ride because of its visibility to their peers.

Their increased motivations could also elicit traits of exercise addiction. This has been notable where cyclists have continued to exercise through an injury or not given themselves enough time to rest. Along with this, some of the motivational factors like graphs and leaderboards (Millington, 2018) have also encouraged them to cycle more frequently and led to feelings of guilt when they are unable to continue a streak or see gaps appear in their timelines. Despite these motivations causing negative effects within their practices, cyclists increasingly saw them as motivating and spoke about it positively.

Using technology also increased their levels of self-surveillance. Cyclists are subjected to analysing their own performances after each ride, as well as being able to see what their peers have achieved. While Strava is not commonly included within Fitspiration social media, it does share some of the traits. Cyclists are not exempt from media portrayals of idealised body types, with professional cyclists' weights spoken about freely and numerous magazine articles about how to lose weight. While the participants were not representative of suffering from increased use of weight loss diets due to their increased exposure to other athletes, many of the participants reported that they were happy with their diet or that they felt they could eat what they wanted due to the amount of exercise they did. It is important, however, to understand that Strava's impact on users' motivations to increase their fitness could lead to negative impacts on their nutrition and diet in the future.

The impact technology had on cyclists' relationships was also explored. The impacts varied amongst the sample, though many of the participants experienced some sort of negative feedback within their relationships. Generally, cyclists experienced frustrations with their spouses due to the increased time spent cycling. In some cases, they had let their cycling become the focus for their family holidays, with events booked in advance while they are away. Like in other aspects of familial life, compromise was often spoken about to alleviate the extra stresses that time spent cycling can add to the relationship. Communication with their partners allowed them to have an open discussion about whether their cycling plans would fit around their familial commitments.

However, not all the respondents were able to mitigate the negative effects on their relationships. The most extreme representations culminated in the end of a marriage for one respondent and another, stating that they would not date someone who was not as active as they are. This highlighted the gender disparity among the respondents. While the majority of cyclists who experienced issues within their familial life referred to compromise and communication as key, they were overwhelmingly male. This further entrenches gender norms that women are to become less independent in marriage and submit to the care of their dependents (Janzen and Cousins, 1995; Nomaguchi and Bianchi, 2004). It is important to consider the role of gender within further research to ensure that gender disparity is not furthered. The increased motivations of women within this research had caused an end to two relationships; much of Strava's platform also (re)inscribes notions of sporting masculinity through its gamification designs.

Despite the negative effects technology can have on the wider aspects of cyclists' lives, it has also been responsible for encouraging them to participate in forms of active transport more regularly. While commuting was not always viable for some of the participants, many of them had considered leaving their cars behind to travel to see friends and family or when undertaking errands. This supports the work that gamification can help to incentivise active commuting and transport. Monetary gains through some initiatives work by increasing short-term motivations in participants but do not result in effective and sustained changes to practices. Extrinsic motivations such as those provided through gamification platforms like Strava were more suited to increasing inherent motivations overall. To elicit consistent changes to habits and routines, respondents need to be subjected to the initiative long enough for meanings of value to be ascribed to the practices (Shove, Pantzar, and Watson, 2012).

Cycling has provided a relevant case study for examining digital creep and the technological practices within exercise. Cyclists' technological practices shape their experiences in everyday life, increasing their motivation to participate in cycling and changing their practices to include more conscientious forms of travel. Generally, technology has provided cyclists with positive experiences; however, as explored above, it can also negatively impact their lives. In this regard, technology both enhances and reduces their experiences. Practice theory has also provided examples of digital creep and how the pervasiveness of digital technology can alter interactions with the physical environment. While this thesis has explored digital creep within the context of cycling, it is apparent that it is part of a wider set of digital practices that permeate all aspects of everyday life.

To summarise, technology plays a mediating role, whereby socio-technical cycling assemblages provide a case study for exploring wider implications of other digitised exercise practices. The sociability provided by applications like Strava helps to encourage participation in exercise due to increased feelings of accountability and replicated social engagement (Chen and Pang, 2012; Rivers, 2020). However, users can also experience negative impacts through its increased use. One key implication is the potential for exercise addiction (Baker, Griffiths, and Calado, 2021), which results in users neglecting personal injuries and relationships. The results of which are experienced to a greater extent by women than men and further exacerbate gender disparity within sports (Janzen and Cousins, 1995; Wellard, 2002; Wiley, Shaw, and Havitz, 2010). Following a practice theory approach and considering digital technologies as an integral element to cycling practices, cyclists' experiences and actions within their everyday lives, both on and off the bike, are affected by their digital counterparts and associated practices.

Chapter 8: Conclusions

8.1 Introduction

Having addressed the research questions through a qualitative methodology, the research has shown how practices of cyclists and technology are (co)produced as socio-technical cycling assemblages. This chapter serves as a culmination of the research and concludes the thesis by summarising the specific themes that emerged from the research in relation to the research questions:

1. What do the narratives and lifecycles of socio-technological practices tell us about the technologisation of leisure practices?
2. How do cyclists' practices change: what are the mechanisms of this change and what are the consequences?
3. What are the implications of these changes in cycling on its growing role in active leisure and transport, and what are the wider lessons with respect to the pursuit of leisure and in everyday life?

The previous two chapters answered the research questions and provided rich detail about the complex and nuanced relationship between technology and cyclists. These relationships experienced by the respondents have been conveyed as individual fluid elements that have adapted, (co)evolved, and (co)produced their practices. Displaying these elements separately allowed the research to provide a partial understanding of the roles they play within cyclists' practices. Chapter 6 was an empirical review of the respondents' narratives of digital creep. This provided insight into how their practices emerged from their initial recruitment into cycling and then subsequent recruitment into forms of self-surveillance and self-quantification enabled by their socio-technical assemblages. Following this, Chapter 7 provided a discussion about the implications of the changes the cyclists underwent. Borrowing from Michael (2009: 91), the chapter highlights the potential for cyclists to become "cognitively corrupted" by their technologies. However, this research finds Barratt's (2017: 334) "digital imperative" to be a more congruent conceptualisation of riding with digital coagents. Digital imperatives led cyclists to develop a compulsion to track and record their rides, both geographically and in relation to their bodily performance. Considering this, the routinisation of technology into their practices highlights that these digital imperatives are enabled by what can be considered “mundane technologies” (Michael, 2000: 3) and applications that fade into the “taken-for-granted background” (Thrift and French, 2002: 329) of their cycling practices. Yet the power and influence that they can exert over the practitioner is far from mundane.

For the methodological approach, the research used semi-structured interviews that focused specifically on the narratives of the respondents. Narratives were sought through the interviews due to their ability to contextualise (Barbour, 2014) the practices of cyclists. As narrative interviews use a respondent-centric approach (Anderson and Kirkpatrick, 2015) this provided a platform to probe participants’ narratives further to elicit rich and contextual responses. Narrative interviewing requires the use of semi-structured interviews that can vary in their rigidity (Anderson and Kirkpatrick, 2015). The structure imposed on the topic guides served to start narratives and experiences from the respondents while maintaining that they were focused on the technological aspects and experiences of their cycling. Using this interview approach allowed for salient narratives to be gained and for the interview performance to remain fluid, conversational, and relaxed (Barbour, 2014). During the interviews, some participants engaged with their digital technologies or applications like Strava. Their tangible experiences acted as an aid that enabled richer and more experiential dialogues during the interviews.

My positionality as a cyclist allowed for deep insight into the narratives provided during the analysis. As a result, the digital and technology could be considered as more than just “things” (Latour, 2000: 107) but as constituent elements arranged and linked together in practices that are (co)produced (Shove, Pantzar, and Watson, 2012) through the enactment of cycling. Using practice theory as the theoretical approach allowed the research to unpack the heterogeneous relations between cyclists, their technologies, and their experiences of space. The reduction of practices to three constituent elements allowed complex practices to be simplified and understood in terms of their development and propagation (Shove, Pantzar, and Watson, 2012). The consideration of “things” (Latour, 2000: 107) and materiality as constituent elements adds to theories of objects scripting practices (Shove, Pantzar, and Watson, 2012). Along with the inclusion of material objects and further simplification of competencies and meanings, it builds on the work of Reckwitz (2002). Categorising cycling practices into three broad elements as an analytical strategy allowed the research to, as Shove, Pantzar, and Watson (2012: 121) state: “develop a method of thinking about the dynamics of practice, starting from first principles” and “treating elements as building blocks of practice, we have been able to identify emergent patterns and connections and say something about how these are made.”

Therefore, despite the shortcomings of simplifying practices, the research builds on the frameworks for examining practices put forth by Shove, Pantzar, and Watson (2012) and uses the narratives of cyclists to deconstruct their technological practices. Simplifying practices this way acted as a feature aided by the rich, reflective, intellectual, and contextual reflections and narratives that cyclists were able to recount. The result was well-articulated narratives of their own experiences through deep-rooted histories of self-quantification in cycling. Drawing upon Barratt (2017), the practices and engagement of cyclists is of contemporary importance for health promotion both in research and policy. Technology’s role within the cycling practices resulted in digital imperatives and compulsions to ride through cogent scripts modifying the very act and practice of cycling. The narratives of digital creep held within the empirical and discussion chapters elucidate the wider significance of socio-technical interactions beyond cycling and into the everyday lifecycles of technologically mediated interactions.

8.2 Contributions to knowledge

This research contributes directly to geography and practice theory. It builds directly upon the field of digital geographies, particularly understanding the spatial and temporal experiences of socio-technical cycling assemblages, and furthers research into digital leisure practices. These findings come from novel empirical discussions around the narratives of digital creep experienced by cyclists exploring the emergence of their digital practices, the (co)production of leisure through digital technologies, the mechanisms that cause significant and long-term changes to, and the routinisation of digital leisure practices for wider applications. The outcomes of the research are summarised below before outlining further avenues of research into the digital imperatives within everyday leisure, transport, and life.

8.2.1 Digital imperatives and practices of socio-technical cycling assemblages

This research demonstrates that technology is interwoven into the fabric of everyday life and that daily experiences are mediated by a multiplicity of digital interactions. Cycling is no different. The narratives of digital creep explored within this thesis provide deep insight into the important role technology plays in the experiences of cyclists. Digital technology has become integral to their cycling practices. The claim from Kitchin and Dodge (2011) that software is the 'lifeblood' of everyday life remains a salient point that evokes several moral and ethical considerations for applications and technology moving forward. By examining cycling practices, it is apparent that it is experienced through spatial, social, cultural, and technological interactions with augmented realities (Ash, Kitchin, and Leszczynski, 2019; Barratt, 2017). Cyclists are cognisant to the presence of their technologies yet refer to it in terms of mundanity (Michael, 2000) within their cycling routines. Therefore, the research argues that contemporary cyclists operate within coded space (Kitchin and Dodge, 2011) where cycling is not reliant on the technology for the performance. Still, the experience of practitioners is vastly improved by it. The experience of cycling is punctuated by digital imperatives in the wake of scripted experiences. Spatiality is augmented through scripted engagements that demarcate sections of roads into competitive landscapes through digital online leaderboards. Furthermore, cyclists' practices are (re)shaped and (co)produced (Shove, Pantzar, and Watson, 2012) by the very scripts that have become the 'lifeblood' (Kitchin and Dodge, 2011) of their lived experiences. Therefore, the notion that through technology, users are "cognitively corrupted" (Michael, 2009: 91) is replaced with "digital imperatives" (Barratt, 2017: 330), whereby technology plays an integral role in the (co)production of the ride.

While examining the empirical contributions this research has made is important, it is crucial to address the broader implications that extend beyond, the earlier empirical discussions and consider the theoretical contributions to cycling practices and spaces. The narratives of digital creep highlighted the intricate relationship between cyclists and digital technologies and provided a novel lens through which these elements of practice, mobility, and spatiality could be theorised. The research, therefore, broadens debates within digital geographies on how it conceptualises mobilities and spatialities that are increasingly digitally mediated. For increasingly digitally mediated practices to be understood, a more nuanced engagement with digitally engaged participants is required. By examining the digital as an integral component of the participants' practices, it provided deep insight into how their practices are (re)shaped and (co)evolve with their digital companions. Understanding that their experiences and meanings of their practices "may vary as patterns of participation change" (Shove, Pantzar, and Watson, 2012: 62).

Earlier discussions around cyclists' engagement with self-quantification (see Chapter 3) showcased that cyclists have been consistently engaged in quantifying their performances. The advent of smartphones and their ability to render captured data in easily understandable formats (Lupton, 2017; Millington, 2018) ushered in new and novel ways for cyclists to engage with self-surveillance practices that grant them "opportunities to acquire self-knowledge, engage in self-reflection and optimise their lives". This increasing mediation of not only cyclists' practices but also practices in wider everyday life (Leszczynski, 2019) requires a more involved engagement with digital technologies in understanding the transformations of not just active leisure but spatiality as a whole. Using cycling as a case study, the thesis contributes to the understanding of cycling in an era of accelerated digital experiences but also highlights the importance of including the digital when examining wider pursuits and their spatial interactions.

The emergence of applications like Strava led to narratives of digital creep from the respondents. Their use of smartphones and social media applications allowed for new digital cycling practices to develop and become popular among the cycling community. These narratives were imperative to understanding the changes experienced within the cycling community and underscore notions of hybrid, augmented, and coded spaces that blur the lines between physical and digital spaces as separate entities (Ash, Kitchin, and Leszczynski, 2019). It was important to explore these narratives as they went "into detail, and it needs details because they add to the story, provide evidence for it, and help to explain what really happened" (Law, 2002: 188). This thesis contributes to the understanding of spatialities and encourages a rethinking of how physical spaces are navigated, consumed, and experienced. The research agrees with Wilson (2014: 535) that the "continuous connectivity" of these technologies "underlies the development of digital spatial media and influences the contemporary production of spatial knowledge". New technologies such as dedicated GPS devices emerged, and as such, cyclists were enabled to track longer rides and monitor their bodily capacities in new ways, and the functions of new technologies became entangled within their practices. Cyclists operate in a coded space (Kitchin and Dodge, 2011), and the gamification of physical environments through scripted engagements illustrates how these digital imperatives have (re)shaped the geographies of cycling.

New technological developments transformed bodily functions into binary representations. Technology like cadence sensors, heart rate monitors, and power meters enable cyclists by providing them with a panoptic view and a deeper understanding of their overall health and fitness. Quantification of bodily functions modified the experiences and physical outputs of cyclists. From the information displayed on their dedicated GPS devices, their interactions with space were mediated by technology; low power numbers could motivate users to try harder, or high heart rates could inform them to ease off. Through technology, the ride is (co)produced and choreographed. The experiences of the respondents were improved by technology, particularly in conjunction with applications like Strava. The combination of bodily sensors, recording of rides, and post-ride analysis is a ritualised part of cycling practices. However, there are implications for future mobile health practices whereby cycling for personal fitness and fun becomes concomitant with mobile health monitoring and health insurance policies (Till, 2014).

Narratives of digital creep identified that technology and applications played a key role in “scripting human and non-human actors” (Shove, Pantzar, and Watson, 2012: 59). Gamified scripts on Strava allowed it to become a prominent feature of digital cycling practices. The research has built on the initial work of Barratt (2017) and furthers the understanding of the effect gamified scripts have on cyclists. It has also shown that the lifecycles of technology are continuously (co)evolving. Segment leaderboards that once provided intense online competition amongst peers and strangers are now used to aid specific training and facilitate self-quantification. While Barratt (2017) found that the challenge feature resulted in increased riding, it has now come to be seen as a mundane aspect of the technology that fades into the background of the application. Moreover, in-depth training analysis has become a feature that has allowed cyclists to train more specifically and examine their fitness trends over time. Detailed analysis of their bodily exertions strengthens Lupton’s (2014a; 2016a; 2017) notions of self-quantification that lead to motivational changes that encourage them to continually train and strengthen the role technology plays within their cycling practices.

A consequence of technology has led to the very practice of cycling being contingent on its presence. While cycling operates within Kitchin and Dodge’s (2011) coded space, the performance is enhanced through digitally mediated interactions. Michaels (2009) suggested that such a reliance on technology can lead to cognitive corruption; it could be argued that the presence of technology has led to the corruption of some of its users and, indeed, some of the respondents. However, this research argues that it is not cognitive corruption but a compulsion to self-surveillance through what Barratt (2017) terms a digital imperative. The research includes a number of these digital imperatives, notably where cyclists are reluctant to ride without their technology, waiting for it to charge before they conduct their ride. Compulsions to record data regardless of its use are also found within the research, further highlighting how technology has become contingent to the ride. Technological dependence experienced by cyclists within this research further proves that exercise and leisure has transitioned into what Millington (2018) calls Fitness 2.0. The research has shown that the practices of cyclists are fluid and that "traces of the past are inscribed in the patterns of the present" (Shove, Pantzar, and Watson, 2012: 125), where previous forms of quantification provided the requisite skills and competencies that transferred with the digital turn in cycling technology. Cyclists are socio-technical assemblages, and each subsequent performance with technology reinforces their dependence on the technology. As a result, cyclists are imbued with a digital imperative.

8.2.2 Implications of digital imperatives and socio-technical assemblages

Cyclists have proven to be a useful case study for understanding the propagation of socio-technical practices. The result of this thesis has highlighted the consequences and wider applications this research can offer to the fields of active leisure and transport practices and the role technology can play within them. Practice theory has proved to be a valuable framework for understanding how long-term habit and routine changes are achieved, and through practice theory lies the potential to influence and inform everyday life and policy (Shove, Pantzar, and Watson, 2012). Digital imperatives bring with them some moral and ethical considerations that need to be addressed as technology moves forward. A significant factor in the popularisation of applications like Strava was its gamified scripts, such as segments and challenges (sections 6.15.1 and 6.15.2). As Perez's (2020) theory of the default male suggests, the scripts that influence the motivations and practices of cyclists are inherently masculine. It is ethical considerations like these that the motivations of practitioners must be considered when developing technology and applications during the era of accelerated digital experiences.

Chapter 7 highlighted and considered the implications and consequences that arise from the socio-technical assemblages identified in the empirical work of Chapter 6. The research found that technology positively enhances the cycling experience for the respondents; however, application developers, local governments, and policy initiatives must consider the potential for the negative implications such technology can have.

As active leisure and transport are becoming increasingly important within new policy initiatives, it is important for the UK government to consider the implications digital technologies can have on the successful implementation of policy. While there has been some short-term success with initiatives such as Beat the Street (Coombes and Jones, 2016), for long-term changes to practices to be established, it is important to consider the findings outlined below. However, while Strava has been particularly successful in influencing the practices of cyclists, it is imperative that the developers of Strava and future application developers consider the wider needs of all their participants to avoid widening the gender gap within sport participation and exacerbating sporting masculinity (Wellard, 2002).

The research found that there are inherent elements and scripts that influence cyclists' digital imperatives that need careful consideration. By exploring respondents' use of self-quantification, the thesis was able to identify how their bodily perceptions were altered from the data they received and how their digital engagements could manifest in real-world alterations to their practices. These scripts carry with them both positive and negative influences. Chapter 7 identified how Strava influenced the practices of male and female riders differently while also highlighting differences within the same gender. This exploration into the changes of respondents’ practices showed that applications like Strava can elicit increased motivations through self and social surveillance. Such online spaces have transitioned into social communities where like-minded individuals can share their everyday experiences (Ash, Kitchin, Leszczynksi, 2019).

Adding to wider debates about the body and how it is conceptualised through their use of digital technologies, the thesis found that cyclists' digital experiences are deeply embedded within digital networks that can (re)shape their self-perception when opened up to the increased social scrutiny offered by applications such as Strava. Leary (1996) stated that self-presentation and the enhancement of social standing are integral to motivation to participate in exercise. This is supported through the research that found social experiences provided by Strava were actively engaged with and the publication of rides online increased users' motivation and held them more accountable. The accountability of publishing rides on Strava led to respondents reporting they rode more frequently due to the added social pressure. However, the implications of social surveillance meant that cyclists were open to closer scrutiny of their performances by their peers, resulting in them becoming what Schlosser (2019: 11) termed "performers".

Despite the social pressures experienced by cyclists, the social integrations in Strava's platform strengthened the experiences of respondents and as in an important factor into its continued success. When considering new policy initiatives to encourage more forms of active leisure and transport, it is important for local governments and councils to consider including social aspects within their policy design. However, while there are benefits to recording and sharing rides on Strava, there are a number of wider criticisms that should be addressed for the platform to ensure it remains inclusive moving forward. While the social aspects of Strava provided users with a sense of camaraderie, the features could also result in symptoms of exercise addiction and over-training. Contemporary research suggests that cyclists are particularly prone to experiencing exercise addiction (Torner-Quiñones *et al.,* 2019; Baker, Griffiths, and Calado, 2021). These claims were supported by the research which found cyclists to continue to ride despite injuries to maintain fitness, or to maintain a consistent online digital profile. It is important to note that the scripts themselves are not designed to elicit these practices but that they are the outcome experienced by some users. Therefore, although the research has shown that motivation is (co)created through the use of technology, practices can (co)evolve, which leads to detrimental experiences of health and personal relationships.

Another key finding was the disparity between male and female respondents. This was particularly evident within discussions on household dynamics. Cycling is an already gendered sport, and this was reflected in the sample stratification that closely resembled the makeup of cycling within the UK (Section 5.3). Within these discussions, it became apparent that there were disparities in how increased motivation and exercise participation caused friction within relationships. In support of Barratt (2017), this builds upon his initial findings and identifies the unequal opportunities for equal participation. As a result of this, there are clear ethical and moral responsibilities that applications like Strava must consider how scripts can affect participation in sport. This must be considered by application developers such as Strava to prevent any inequality from progressing further. Ensuring equal opportunities and representation is crucial as participation rates within sport for women are already lower than men (see The Lancet Public Health, 2019); this is also reflected in sports participation research (Costello, Bieuzen, and Bleakley, 2014).

From the research, it is clear that the outcome of increased motivations and participation in exercise resulted in more serious repercussions for female participants. Again, these findings agree with Nomaguchi and Bianchi (2004), who found that women in committed and marital relationships exercised less than their male spouses. One caveat from the research was that all but one respondent was actively using cycling technology within their riding. As such, this is not a full representation of the barriers to both cycling and cycling technology experienced by women. However, as Perez (2020: XII) writes:

> "[in] a world increasingly in thrall to data. Big Data. Which in turn is panned for Big Truths by Big Algorithms, using Big Computers. But when your big data is corrupted by big silences, the truths you get are half-truths at best. And often, for women, they aren't true at all."

The ‘big silences’ referred to in the quote above currently stand unaddressed within much of the virtual and online sporting environments that continue to reinscribe values of sporting masculinity (Wellard, 2002). This is a salient point with contemporary research attempting to address these gender disparities (see Pooley *et al.,* 2011; Goldbuff and Aldred, 2012; Aldred, 2013; Aldred and Jungnickel, 2014; Davidson, 2021). Therefore, analysing socio-technical cycling assemblages provides an understanding of the failings of digital technologies and their scripts at fully addressing the needs of women participants. Consequently, the research has found that due to a lack of participation rates, women are not seen as consumers within a male-dominated market, and that their needs are assumed to be equal to that of their male counterparts. In agreement with Reed *et al.* (2022), much of the technology has inadvertently designed technology that reaffirms the ‘male gaze’.

Despite the gendered shortcomings of Strava, the research highlighted how technology can be used to increase motivation and encourage participation in active leisure and transportation. The research found that the motivations of respondents were increased due to their use of technology and that self-surveillance, self-quantification, and social surveillance resulted in enhanced experiences. Extrinsic motivators like Strava’s segment and challenge features provided users with augmented experiences that improved their overall experience during and after the ride. The social integration built into Strava also facilitated long-term changes to practices. Following the findings of Thiel (2016), the inclusion of social interactions and extrinsic motivators, such as the gamified scripts of Strava, should be considered integral to the successful implementation of future gamification efforts. However, it is also pertinent to consider potential side effects of the scripts that could lead to negative experiences like those outlined above.

Furthermore, the routinisation of digital practices showed how technology has become subsumed into the pursuit of cycling. Although self-quantification was present amongst cyclists, the propagation of technology in recent years has led to the mass adoption of digital technologies. Technology has become entangled within the practices of cyclists and, as a result, has become routinised. Such routinisation was evident as technology was referred to and compared to other mundane objects (Michael, 2000) within their cycling assemblages. It is clear that through consistent (re)enactments, technology's role within the practices of cycling has become axiomatic, whereby their experiences are contingent to its presence.

Researching cycling also contributes to understandings of other technologised pursuits. As Kitchin and Dodge (2011: 7) write:

> "That such coded objects, infrastructures, processes, and assemblages exist widely and do work in the world is itself a function of the rapid advances in hardware and the exponential growth in digital computation at increasingly reduced costs, along with the ability to access such computation at a distance".

Everyday life has entered an era of accelerated digital experiences, and the narratives of digital creep expressed within this research highlight the capacities in which technology can elicit significant changes to practice. The insights gained from a practice theory approach to understanding change in cyclists can be applied to understand how technology mediates, (co)produces, and (co)evolves with other leisure practices.

The evidence presented in this research has suggested that technology has led to significant changes among cyclists, and their practices have become subsumed by their digital counterparts. At each stage of their rides, technology is actively considered, through pre-ride routines that ensure the technology is present and working, to during-ride interactions that alter the corporeal outputs of cyclists, and finally to the post-ride examination of their digital artefacts. The previous chapters examined the aspects of technology separately to understand the individual effects they have upon the cyclists that are engaged. This separation allowed the research to demonstrate their combined relevance to the practices of cyclists and to understand the wider dynamics digital practices can play in everyday life and the implications this can have for informing future policy debates.

In summary, from the narratives of digital creep showcased amongst the cyclists interviewed for this thesis, it is apparent that technology plays an important role in empowering (Lupton, 2017) users by promising greater insights into their overall health. While the outcomes experienced by the participants were overall positive, there are considerations that need to be made to address the potential for exercise addiction, distortions in bodily appearance, and eating disorders. As new policy initiatives are developed, it is important that the effects of digitally mediated practices are considered to help facilitate long-term changes within mobility practices. The inclusion of social integrations within initiatives can strengthen participants' sense of camaraderie and motivation to participate. As governments work towards encouraging active leisure and transportation, the use of digital applications can provide a good starting point to influence changes in practice. However, governments and application developers like Strava must consider the effects that the scripts of such applications can have on furthering sporting masculinity (Wellard, 2002) and increasing the divide between male and female participation (Barrie, Waitt, and Brennan-Horley, 2019). This research has shown how the digital practices of cyclists have become embodied within their experiences, and the consideration of digital practices is important in future investigations into the geographies of mobility and spatiality. Practice theory has proved to be valuable in exploring the dynamic role of technology, and that extends beyond cycling and into wider debates about technology and everyday life. Although there are some similarities between the findings of Barratt (2017), cyclists remain complex socio-technical assemblages that continually (co)evolve with their technologies, not only as new technologies are developed but also as existing ones transition into the background of their assemblages.

8.3 Further research

This thesis has drawn upon a number of theoretical frameworks within geographical and sociological fields of research. Notably, the use of practice theory has been integral to examining the changes cyclists' practices have experienced through their technological engagements. This proved integral in exploring how their spatial practices are augmented by the digital and how the blurring of physical and digital spaces has become increasingly present in everyday life. As such, theories of digital geographies have also been essential to this conceptual understanding of cycling as a socio-technical assemblage. The research initially set out to understand how the practices of cyclists are changed by technologies and how these understandings can be applied to wider research in active leisure and transportation practices. However, from the interviews, it became apparent that the increased motivations experienced by cyclists can exacerbate gender inequalities within the pursuit. Cycling is a pursuit that can regularly take several hours for a ride, particularly for experienced cyclists. Subsequent interviews enquired about the home dynamic and issues that can arise through increased motivations caused by digital practices. However, more comprehensive discourse is needed to understand the extent of the impact technology can have on familial roles, with a particular focus on the differences experienced according to gender.

The findings of this research highlighted the stark contrast in gender representation both in participation within cycling but also the representation of women through online applications. With an increasing focus on gamified efforts to increase participation in active leisure and transport (see Coombes and Jones, 2016; Thiel, 2016), there needs to be a concerted effort to ensure the needs of women are actively considered. While the research has shown those already engaged with applications like Strava participate in digital competitions like segments, efforts must be made to ensure that future endeavours are not based upon notions of sporting masculinity (Wellard, 2002). There is clear potential for further research into ensuring women are more widely represented in the growing role of digital sporting technology, not only for those who are already actively participating but also to ensure that the barriers to female participation are lowered to not further increase gender disparity.

As the research and interviews took place throughout the COVID-19 pandemic, they also highlighted the growing role virtual platforms began to play within cyclists' experiences and training regimes. Platforms like Zwift have become increasingly popular, particularly during the COVID-19 pandemic. It was evident that through the regulations and lockdowns implemented in the UK (and worldwide) led to increased participation amongst the interviewees. Future research endeavours could examine the various virtual platforms that have become popular for indoor training. These indoor pursuits bring with them different socio-technical assemblages with smart indoor trainers connected to computers that endeavour to transform indoor experiences into close representations of the outdoors. Endeavours into these virtual worlds would reveal further insights into increasingly digital practices and how physical spatialities are further transformed and augmented by virtual experiences.

8.4 COVID-19

Due to the conditions of the COVID-19 pandemic, the recruitment of participants was widened to the whole of the UK. This allowed the research to gain a representation of cyclists' experiences of technologies from a range of cities, towns, and villages around the UK. Restrictions put in place by the UK government also meant that many of the interviews took place virtually. The need to adapt to a rapid shift in sociability throughout the UK was also experienced within the cycling practices of many of the respondents. As outlined above, participation in online virtual platforms like Zwift grew in popularity amongst the cyclists interviewed. While a thorough investigation into the growth of these virtual platforms was out of the scope of this research, it highlighted how quickly practices can emerge and the effects they can have on the regimes and routines of everyday lives. With adaptations and changes to work schedules, the facilitation of flexible working and working from home led to increased flexibility within daily schedules.

Changes to working schedules and the increased time flexibility encouraged many respondents to ride more frequently, both inside and out. The inclusion of online virtual platforms further changed the spatial representations and experiences of cycling. Social interactions were increasingly mediated through digital technologies through Zoom calls and video chats. Platforms like Zwift and Strava allowed cyclists to remain connected to their wider cycling networks. While there is contemporary research into the experiences of virtual platforms such as Zwift (see Reed *et al.,* 2022), further research would benefit in understanding the mechanisms of rapid social change and the implications this could have in facilitating engagements in active leisure, transport, and policy.

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Appendix 1: Interview Consent Form

DEPARTMENT OF GEOGRAPHY, SAFFORDSHIRE UNIVERSITY
CONSENT FORM: INTERVIEW
Narratives of Digital Creep: An Investigation of the Socio-technical Transitions in Cycling

I,

Hereby agree to participate in this study to be undertaken by Adam Caine. I understand that the purpose of the research is to investigate GPS-enabled cycling applications. This interview will explore how such applications can be used to help support cycling infrastructure planning and how current planning can be improved by their use.

I understand that:

1. My interview will be transcribed and coded. My name and address kept separately from it.

2. Any information that I provide will not be made public in any form that could reveal my identity to an outside party. I will remain fully anonymous (unless permission is sought to the contrary).

3. Aggregated results will be used for research purposes and may be reported in scientific and academic journals.

4. Individual results from this interview **will not** be released to any person except at my request and on my authorisation.

5. I am free to withdraw my consent at any time during the study, in which event my participation in the research will immediately cease and any information obtained from me will not be used.

Signature:

Contact details of the researcher: Adam Caine, Department of Geography, School of Creative Arts & Engineering, Staffordshire University, ST4 2DF
E-mail: adam.caine@research.staffs.ac.uk

Contact details of researcher supervisor: Dr Paul Barratt Department of Geography, School of Creative Arts & Engineering, Staffordshire University, ST4 2DF
E-mail: P.Barratt@staffs.ac.uk

Appendix 2: Initial Interview Topic Guide

Introduction:

How long have you been cycling for? How did you get into cycling? Do you cycle often?
What is your preferable type of cycling? How would you define yourself as a cyclist?
What are the main pieces of equipment you take out on each ride?
Does this change depending on the type of ride? Whet made you buy the equipment you currently use? What would make you update your equipment?
What was the last piece of technology you bought, Why did you buy it?
What is your favourite bit of technology, what does it do?

Cycling kit:

Has any of the technology you bought changed the way you cycle? How much?
Do you think they have altered your experience of cycling?
How do you use these technologies during cycling? Does it change what you do physically or mentally?
How long did it take for you to get comfortable using this technology?
Has technology become part of your cycling? Does this affect the experience for you?
Does technology change where you cycle? Are your routes informed by the use of technology?
Has this technology become part of your routine for cycling? Has your perception to the technology changed one twice?
Do you think that technology has changed the ephemeral nature of cycling?
Has the social aspects of your cycling changed through the use of technology? How?
Do you take part in any of the competitive parts of cycling?
How have your motivations towards cycling changed through the use of technology?

Has technology had any effect or the type of training you do?
Do you use technology to track any biological data? (HRM, Power, feel).
Do you ride with any groups / clubs? Have you noticed any changes in Group dynamics through technology?
How do you use segment features on technology? Does your route choices change because of this?
what are the specific aspects of the technology do you use?
Why do you use technology for cycling?

Behaviours:

Has the use of technology changed other aspects of your life? (Better diet, rest days, Replacing Car journeys, cross-training, Positive or negative health).
Are there any issues in your home life due to time spent cycling?
If children: do you find yourself involving your children in cycling?
Have your behaviour towards cycling changed since the use of technology?
Did you experience an increase in the amount of cycling you do Since you started using technology?
Do you actively try to beat your own or friends previous times on segments?
Do you consider how you ride will appear to your peers? What do you think a good ride looks like?
Does the type of weather conditions change the routes you cycle?
Are there any aspects of technology that you avoid using? What are these? Why won't you use them? Do they alter your enjoyment?
Do you feel that some aspects of technology encourage you to take risks when cycling? How do you feel about this? Do you think that this risk is increased because of technology? Could it be reduced at all?
What impact has technology had on your cycling experience?
with the increase in cycling participation have you noticed any changes amongst the cycling community?
Do you think technology is just part of cycling culture and practices now?
Do you think that the increased popularity of the sport has altered the prevalence of technology?
Has technology altered the way you interact with the physical environment?

Appendix 3: Revised Interview Topic Guide

Cyclist Interview Questions

Background Questions

1. How old are you?
2. How long have you been cycling?
    a. How did you get into cycling?
    b. How often do you cycle?
3. What is your preferable type of cycling? (Road, MTB, Cross, etc)
    a. How would you define your ability as a cyclist?
4. What are the main pieces of technology that you take out on a ride with you?
    a. Does this change depending on the type of ride?
    b. What made you buy the equipment you currently use?
    c. What would make you update the equipment?
5. What was the last piece of technology that you bought?
    a. Why did you buy it?
6. What is your favourite bit of technology?
    a. What does it do?
    b. Why is that your favourite?
7. How long did it take you to get comfortable using this technology?

GPS Devices

1. Has any of the technology you bought changed the way you cycle?
    a. How much?
2. How do you use these technologies during cycling?
    a. Does it change what you do physically or mentally?
    b. What data do you look at most?

        i. Speed, Heart Rate, Cadence, Average Speed, Elevation, Distance, Time, Effort?
    c. Why?
3. How does technology change your experience on the bike?
    a. Better?
    b. Worse?
4. Have you used the GPS device for route choice?
    a. Does this change through the technology?
5. Do you think the use of technology has altered the ephemeral (in the moment, fleeting) nature of cycling?
6. Has technology become part of your cycling routine?
    a. Does this have an effect on your experience?
7. If you found your device had no charge or low battery would you wait for the device to charge before going out?
    a. Why?
8. If you forgot your device would you go back to get it?
    a. Would you use your phone instead?
    b. Has this ever happened to you?
        i. How did you feel?
        ii. What did you do?
9. Have you found your motivations have changed since using GPS devices?
    a. How?
10. Has the type of training you do changed since you started using technology?
11. Did you begin tracking your rides when you got a GPS device?
    a. Did you use a Smartphone first?
    b. Why did you upgrade to a GPS device?
    c. Did you find it was a beneficial change?
    d. Did it improve your overall experience?

Strava: Features, Metrics, Social, and Relationships

1. Do you commute to work on your bike?
    a. Do you mark your rides as commutes?
2. Do you use the Strava FlyBy feature?
    a. Do you look at their route?
        i. Do you consider the difficulty of their ride?
    b. Do you compare their effort to your own?
    c. Why do you do it?
    d. Does it have any effect on your motivation?
3. Do you use any of the training features on Strava?
    a. Training Log or Calendar?
4. Do you take part in any of the competitive aspects of cycling on Strava?
    a. Do you take part in the Challenges?
5. Do you find that you've become competitive online?
    a. What about with strangers on segment or challenge leader boards?
    b. Your friends?
    c. Yourself?
6. Are you a Strava Summit (Paid) member?
7. Do you look at your suffer score?
    a. How does that make you feel?
    b. What about the fitness and freshness feature?
    c. Are there any metrics that you consider to aid your training?
    d. Do you find the metrics help you in any way?
    e. Have they had an effect on your training or riding?
8. Have you ever used one of the online training plans?
    a. Yes
        i. What made you consider this?
        ii. How did you find it?
        iii. Did you stick to the plan and complete it?
    b. No
        i. Would you ever consider using one?
        ii. Why?
9. Have you experienced any changes in your use of technology and applications (Strava) over time?

   a. How has your relationship with the technology or applications changed over time?
   b. Do you use them out of habit?
   c. Is it something that you enjoy using?
      i. Why?
   d. What would make your experience better?
10. How does seeing a decline in performance make you feel?
    a. Do you feel less fit because of it?
    b. Do you think that age has a factor on your performance?
    c. As time goes on do you feel that your maintain your motivation?
    d. Are you still competitive?
11. Does your device have Live Segments?
    a. Is it something that you use?
    b. How does that affect your ride?
    c. How does it affect that moment during your ride when it comes up?
12. How do you feel about the phrase “If it’s not on Strava it didn’t happen”?
    a. Have you ever used the phrase?
    b. Has it ever been said to you?
13. Why do you use these technologies and applications?
14. Have you found that technology has changed the social aspect of cycling for you?
    a. Do you use engage with other people’s rides? (Kudos, Comments)
    b. Have you noticed any changes in group or club rides?
       i. Are people using the technology?
       ii. Are they participating in Segments or Challenges?

Zwift / Virtual Platforms, and Gamification

1. Have you had any engagement with digital online rides?
   a. Would you consider using Zwift or Sufferfest?
2. Have you used any of the training plans on Zwift or Sufferfest?

    a. Have you taken part in any of the online races or competitions?
3. Would you choose and indoor ride over an outdoor ride?
    a. Why?
4. Does the virtual game like interface help to keep you motivated?
    a. Why?
    b. Do you engage with the chat or “ride on” features?
5. What about the training tools?

Behaviour: Stories from cyclists

1. Have you ever had an experience where Strava just went wrong?
    a. Tell me about it?
    b. How did it make you feel?
    c. What did you do about it?
    d. When did you realise?
2. Why did you join Strava?
    a. What made you join?
    b. Did you start tracking you rides straight away?
3. Did you ever track your rides before you started using Strava?
    a. What did you use?
    b. Were you hesitant about tracking your rides?
    c. What made you start tracking your rides?
    d. How did you start?
        i. Phone, GPS Device, Pen and Paper?
4. What effect do you think all this technology has had on your overall experience?
    a. Are you sure it has had no effect?
5. Have you experienced any issues in your home life due to time spent cycling?
    a. How do you manage this?
    b. Is your partner active?
6. Have you included children in cycling?
7. Do you think that technology has altered any other aspects of your life?

    a. What is your diet like?
    b. Do you have enough rest days?
    c. Have you ever considered replacing car journeys?
    d. Do you do any other forms of exercise?
8. Did you experience an increase in the amount of cycling you did when you started using technology?
9. Describe your ideal ride to me
    a. What would that look like on Strava?
    b. How do you think that would come across to your peers?
        i. Do you ever consider how your rides will look to your peers?
10. Does the type of weather ever change your ride?
    a. Would you target a specific segment because of this?
11. Tell me about how you manage risk when you're out cycling?
    a. Have you ever taken a risk because of a segment?
        i. Would you?
    b. How do you feel about risk?
    c. Do you think anything can be done by technology and applications to reduce risk?
12. Do you think that technology has just become part of practice and cycling culture now?
    a. Can you talk me through your pre ride routine?
        i. Getting ready
13. Have you noticed any changes with how you interact with the physical environment?
    a. What about when you're on a segment?
    b. Do you actively take stock of your surroundings?

Appendix 4: Research Ethics Form

RESEARCH ETHICS
Proportionate Review Form

The Proportionate Review process may be used where the proposed research raises only minimal ethical risk. This research must: focus on minimally sensitive topics; entail minimal intrusion or disruption to others; and involve participants who would not be considered vulnerable in the context of the research.

PART A: TO BE COMPLETED BY RESEARCHER

Name of Researcher:	Adam Caine

Student/Course Details (If Applicable)			
Student ID Number:			11018211
Name of Supervisor(s)/Module Tutor:			Dr Paul Barratt
PhD/MPhil project:	☒		
Taught Postgraduate Project/Assignment:	☐	Award Title:	
Undergraduate Project/Assignment:	☐	Module Title:	

Project Title:	Mobile Technologies, Leisure, and Big Data: How they influence user interactions, and can they be used to support cycling in the Peak District National Park.
Project Outline:	This project will be focused on the emerging area of technologised engagements with the environment. As of 2016 Strava logged a total of 136 billion data points with London uploading more rides than any other city in the world (Strava, 2016). As this data is readily being volunteered by users it is a treasure trove of information that is currently not utilised in furthering the accessibility and promotion of cycling. This research will explore the experiences and engagements with places and the world in which we interact, focusing on the mobile technologies and the geographically orientated applications associated with these interactions. The datafied space is moving away from in the moment experiences to being able to relive through data and information the spatial interactions, using ANT the research can explore further the narratives that are being recorded digitally and how they are starting to alter and underpin the physical interactions with the environments (Barratt, 2011; 2012; 2016; Sumartojo et al, 2016). This area is still emerging and this research aims to stay at the forefront and develop further understanding in the emerging field.
Give a brief description of participants and procedure (methods, tests etc.)	Participants: Cyclists aged 18+ years, male and female. Questionnaires: Self submission questionnaires sent online invlovling questions about cyclists behaviour from the use of an online application used for recording cycle rides. A mixture of Closed and Likert Scale questions will be used to gather data. Focus Groups: Small semi structured interview focus groups will take place to discuss how cyclists interact with the spatial environments they use. Semi structured approach will be used to encourage a more open discussion.

	Interviews: Semi structured interviews will be used with individuals in local councils and government positions, and the Peak District National Park Authority. Questions will be aimed at finding out about how cycling infrastructure planning is conducted and how it is implemented from planning stages. Ethnographic Interviews: Ride-along interviews: Interviewsing participant about deciseions made while cycling to get real time data about how the spatial environment affects the decisions made. Video Ethnography: Cyclists are recorded from third person and then the footgae is watched back with the cyclist to discuss the decisions they made during the ride. Video Auto-ethnography: Cyclist wears a helmet camera, and has a camera pointed at them to record their interactions with the environment. Footage is watched back with the cyclist present to discuss how they interacted with the environment.		
Expected Start Date:	01/09/2017	Expected End Date:	30/09/2018

Relevant professional body ethical guidelines should be consulted when completing this form.

Please seek guidance from the Chair of your Faculty Research Ethics Committee if you are uncertain about any ethical issues arising from this application.

There is an obligation on the researcher and supervisor (where applicable) to bring to the attention of the Faculty Ethics Committee any issues with ethical implications not identified by this form.

Researcher Declaration

I consider that this project has no significant ethical implications requiring full ethical review by the Faculty Research Ethics Committee.	☒

I confirm that:		
1.	The research will **NOT** involve members of vulnerable groups. Vulnerable groups include but are not limited to: children and young people (under 18 years of age), those with a learning disability or cognitive impairment, patients, people in custody, people engaged in illegal activities (e.g. drug taking), or individuals in a dependent or unequal relationship.	☒
2.	The research will **NOT** involve sensitive topics. Sensitive topics include, but are not limited to: participants' sexual behaviour, their illegal or political behaviour, their experience of violence, their abuse or exploitation, their mental health, their gender or ethnic status. The research must not involve groups where permission of a gatekeeper is normally required for initial access to members, for example, ethnic or cultural groups, native peoples or indigenous communities.	☒
3.	The research will **NOT** deliberately mislead participants in any way.	☒
4.	The research will **NOT** involve access to records of personal or confidential information, including genetic or other biological information, concerning identifiable individuals.	☒
5.	The research will **NOT** induce psychological stress, anxiety or humiliation, cause more than minimal pain, or involve intrusive interventions. This includes, but is not limited to: the administration of drugs or other substances, vigorous physical exercise, or techniques such as hypnotherapy which may cause participants to reveal information which could cause concern, in the course of their	☒

Signature of Supervisor:		Date:	Dr Paul Barratt 06/09/17

Next Step: Please forward this form to the Chair of Faculty Research Ethics Committee who will arrange for it to be considered by an independent member of the Faculty Research Ethics Committee, having no direct connection with the researcher or his/her programme of study.

PART C: TO BE COMPLETED BY FACULTY RESEARCH ETHICS COMMITTEE MEMBER

This research proposal has been considered using agreed University Procedures and is now approved.	☒
Or	
This research proposal has not been approved due to the reasons given below.	☐

Name of Reviewer:	Dr Liz Young	Date:	06/09/2017
Signature:			

Proportionate Review

	everyday life.	
6.	The research **WILL** be conducted with participants' full and informed consent at the time the study is carried out: • The main procedure will be explained to participants in advance, so that they are informed about what to expect. ☒ • Participants will be told their involvement in the research is voluntary. ☒ • Written consent will be obtained from participants. *(This is not required for self-completion questionnaires as submission of the completed questionnaire implies consent to participate).* ☒ • Participants will be informed about how they may withdraw from the research at any time and for any reason. ☒ • For questionnaires and interviews: Participants will be given the option of omitting questions they do not want to answer. ☒ • Participants will be told that their data will be treated with full confidentiality and that, if published, every effort will be made to ensure it will not be identifiable as theirs. ☒ • Participants will be given the opportunity to be debriefed i.e. to find out more about the study and its results. ☒	☒ N/A ☐

If you are unable to confirm any of the above statements, please complete a **Full Ethical Review Form**. If the research will include participants that are **patients,** please complete the Independent Peer Review process.

Supporting Documentation

All key documents e.g. consent form, information sheet, questionnaire/interview schedule are appended to this application.	☒

Signature of Researcher:		Date:	A. L. Caine 04/09/2017

NB: If the research departs from the protocol which provides the basis for this proportionate review, then further review will be required and the applicant and supervisor(s) should consider whether or not the proportionate review remains appropriate. If it is no longer appropriate a full ethical review form **MUST** be submitted for consideration by the Faculty Research Ethics Committee.

Next Step:

STUDENTS: Please submit this form (and supporting documentation) for consideration by your Supervisor/ Module Tutor.

STAFF: Please forward this form to the Chair of Faculty Research Ethics Committee who will arrange for it to be considered by an independent member of the Faculty Research Ethics Committee.

PART B: TO BE COMPLETED BY SUPERVISOR/MODULE TUTOR (If Applicable)

I consider that this project has no significant ethical implications requiring full ethical review by the Faculty Research Ethics Committee.	☒
I have checked and approved the key documents required for this proposal (e.g. consent form, information sheet, questionnaire, interview schedule).	☐