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RESEARCH ARTICLE

Disruption, an Opportunity to Facilitate a Long-Term Modal Shift to Cycling? Stories, Lessons and Reflections From the COVID-19 Pandemic

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The study utilises the 'natural experiment' of COVID-19 to explore how disruption affected individuals' perceptions and experiences of cycling, through semi-structured interviews with eight cycle-shop owners and 30 residents in the Liverpool City Region, UK. It provides an account of the rapidly changing conditions that helped to support greater participation in cycling. Primarily this was due to reduced conflict between cyclists and others for road space. This was supported, though less significantly, by the provision of temporary cycling infrastructure as well as diminished competition for an individual's time and energy from alternative leisure activities which were outlawed through COVID-19-related regulations. By disrupting car-dominated environments, the change in infrastructure and reduction in traffic flows contributed towards reducing the skills and confidence required to begin cycling. Nevertheless, as traffic rebounded to pre-pandemic volumes it was evident that the opportunity offered by disruption failed to be fully realised within the region. Despite this, the period has illustrated the potential for broader participation in cycling, though the paper finds that significant disruption to the infrastructures and traffic flows within the urban environment is required if a long-term modal shift is to occur following the surge in participation in cycling observed during the COVID-19 pandemic. To do so, the paper identifies several interventions that can be implemented to imitate the disruption observed in our study, and in doing so support a transition towards a low-carbon mobility system.

Keywords: cycling; disruption; COVID-19; mobility; sustainability; modal shift

1. Introduction

Prior to the onset of the COVID-19 pandemic the many and varied benefits resulting from an increased participation in cycling, particularly as a result of a modal shift from private motor vehicles, were well known. These benefits can be identified at an individual scale, such as

improved mental and physical health (Mueller et al., 2015), or as a collective benefit, such as decreases in congestion and carbon emissions (Brand, 2021; Litman, 2019). However, as the extent of the pandemic began to be realised, many politicians and policy-makers recognised that active travel offered a low-cost solution to addressing the immediate challenges posed by the requirement for social distancing measures on public transport since it represented a mode of mobility with little risk of COVID-19 infection (Lai, Leone and Zoppi, 2020; Musselwhite et al., 2021).

While the response and impacts of the pandemic differed from nation to nation, the broad effect was a rapid and severe disruption to almost all aspects of everyday life, not least mobility patterns (De Vos, 2020). Social distancing, stay-at-home orders, and the enforced closure of swathes of the economy meant demand for mobility plummeted, and for many travel was legally constrained, such as in the United Kingdom (Cabinet Office, 2020), or strongly discouraged, such as in the Netherlands (Government of Netherlands, 2020). This led to huge reductions in road traffic volumes, public transport loadings, and a near-complete halt to passenger aviation (Department for Transport, 2021; de Haas, Faber and Hamersma, 2020), helping to control and reduce COVID-19 transmission. This led to less-congested roads, cleaner air, and a quieter urban environment; for many cyclists this was a novel and enjoyable experience (De Vos, 2020). This was particularly true for those in nations with relatively weaker "lockdown" measures, such as the UK, which permitted individuals to exercise within their local area (Cabinet Office, 2020).

The pandemic also drew attention to existing arguments for supporting active travel, for example through the identification of obesity and the presence of particulate emissions as risk factors for COVID-19 hospitalisation (Lighter et al., 2020; Wu et al., 2020), alongside a greater recognition and appreciation of safer and quieter urban environments (e.g., Opinium, 2020). Despite the disruption in the volume of motor traffic on roads across the world, including the UK (DfT, 2021; Musselwhite et al., 2021), the urban infrastructure in many localities remained unsuited to cycling (Abdullah et al., 2020). In recognition of this, many national and local governments allocated additional funding to promote cycling, with a key focus being the provision of "pop-up" infrastructures. Lovelace et al., (2020) provide a three-category typology of these interventions: reallocation of road space, temporal closures of whole streets or neighbourhoods, and the use of "contraflow" lanes to promote the principle of "filtered permeability". Typically, a combination of all three approaches formed part of the response, including within the geographical focus of this study, where the Liverpool City Region Combined Authority invested £1.97m in a series of active travel schemes (see Dunning et al., 2021 for details).

The paper first considers how periods of disruption might offer an opportunity to alter an individual's behaviour, including their transportation decision-making. Then the paper sets out a series of studies examining cycling rates and patterns during COVID-19. The findings explore a series of themes which drove an increase in participation in cycling during the pandemic, with the final sections reflecting upon these findings within the broader literature and considering how policy-makers might emulate the conditions seen during the COVID-19 pandemic, to support a long-term modal shift towards cycling.

1.1. Disruption

Disruption is often interpreted as a risk to be minimised and managed, such as in global supply chains (Kleindorfer and Saad, 2005). However, it can also represent an opportunity to challenge established processes and arrangements. By doing so it can help to overcome long-standing societal challenges, not least climate change mitigation, where the transition

towards a low-carbon world is undermined by the deep lock-in to carbon-intensive technology (Markard and Rosenbloom, 2020). The disruption in mobility patterns during the pandemic meant that despite the devastating impacts of COVID-19 upon human health and socio-economic life, there was an opportunity to disrupt the "lock-in" to private motor vehicles, especially in nations including the United Kingdom whose modal share of active travel lags far behind exemplar countries such the Netherlands and Denmark (European Cycling Federation, 2021). The period of disruption represented an opportunity to make longer-term changes to an individual's mobility preferences and habits, given the difficulties in altering preferences in "normal times" (Musselwhite et al., 2021; Schönfelder and Axhausen, 2010).

1.2. Habits, attitudes and behaviours

There is a wealth of evidence examining the factors which are likely to influence the propensity of an individual to cycle or not. This evidence can be interpreted through various models of human behaviour, for example, classical transport modelling (typically informed by rational choice models) emphasises the influence of cost, time, and convenience in modal choice decision-making (e.g., Horowitz, 1993; Morikawa, Ben-Akiva and McFadden, 2002).

Habits also play an important role in sustaining travel behaviour, for example, Rau and Scheiner (2020) and Sigurdardottir et al. (2013) both illustrate how daily travel routines become heavily ingrained in everyday routines. Nevertheless, life-course events including residential relocation and new employment offer an important opportunity to change behaviour since habitual routines are often disrupted and therefore can be more easily altered (Chatterjee and Clark, 2020).

Disruption can also occur through a variety of reasons beyond life-course events and can range from temporary to relative permanence; these periods offer an opportunity for changes in transport patterns and policy (Marsen and Docherty, 2013). For example, Fukii and Garling (2003) studied an eight-day freeway closure in Japan, finding that participants who used public transport during this period were more likely to use public transport in the year following reopening. This was attributed to the disruption breaking long-held habitual travel behaviour.

However, these periods of disruption do not always result in long-term change; for example, Parkes, Jopson, and Marsden (2016) studied the effects of the 2012 Olympic and Paralympic Games in London on commuters' travel behaviour. Although 54% of participants altered their behaviour during the Games, the vast majority reverted to their original behaviours after they ended. Two cases of temporary disruptions to the road network were examined by Chatterton and Parkhurst (2011), both resulting in the local authority funding low-carbon alternatives, which were well-used and popular during the period of disruption. However, they conclude that local authorities did not sustain these alternatives and therefore failed to drive a long-term shift to low-carbon modes of transport, thereby squandering the opportunity offered by the disruption.

1.3. COVID-19, disruption, and cycling

The pandemic disrupted the routines, order, and rhythms of daily life, including cooking, travel, leisure, and working practices (Greene et al., 2022; International Energy Agency, 2020). This enabled a re-evaluation of many aspects of life that were taken for granted, offering an opportunity for social change (Rinkinen, Shove, and Marsden, 2020). This period could be characterised as a risk to a low-carbon mobility agenda since it may have triggered decisions to replace public transport with private motor vehicle use (Chang, Meyerhoefer, and Yang, 2021). However, others emphasised the period as an opportunity to embrace and promote

active travel, such as Nurse and Dunning (2020) and Marsden et al. (2020). To capitalise upon this opportunity, there is a need to understand how the disruption of the pandemic might be harnessed to support a longer-term modal shift towards cycling, providing insights into the interventions which are required to stimulate and sustain such a shift.

The provision and distribution of infrastructure have long been identified as a leading factor in supporting cycling rates in a particular locality (Hull and O'Holleran, 2014; Pucher and Buehler, 2008). For example, many studies link the provision of dedicated infrastructure (e.g. cycling lanes, modal filters, and secure cycle parking) to an increase in cycling rates and a reduction in accidents (Aldred and Crosweller, 2015; Buehler and Pucher, 2021a; Elvik, 2021). The absence of such infrastructures can place barriers to the uptake of cycling, since this can mean that individuals need to possess particular skills and confidence to navigate the car-dominated environments of many urban areas (Cupples and Ridley, 2008). This can create inequalities in cycling rates across different ages (Heesch, Sahlqvist, and Garrard, 2012; Pooley et al., 2013). Such challenges are characterised by Watson (2013, p124) as "systemic sticking points" in the take-up of cycling.

Other competing transport modes can also affect infrastructure availability and perceptions of safety (Watson, 2013). The effects of the lockdown in response to COVID-19 reduced mobility demand leading to "the surprising availability of cycling and walking infrastructure" (Dunning and Nurse, 2020, p1). Elsewhere many urban localities provided new, temporary infrastructures to support active travel. Nikitas et al. (2021) provide a comprehensive review of such measures, highlighting the range of physical interventions implemented by local governments to promote cycling during the COVID-19 pandemic. Kraus and Kock (2021) found that across 106 European cities there was an increase of 11–48% in cycling rates within urban areas where temporary infrastructures were implemented. Fischer et al. (2022) used Strava data to conclude the temporary reallocation of road space helped to support an increase in cycling. However, Nikitas et al. (2021) point out that these improvements were often temporary, with many localities removing such infrastructures in the subsequent months. Such patterns were not universal, for example, Nikiforiadis et al. (2022) and Bucsky (2020) studied the travel behaviour of adults in Greece and Budapest, with both finding there was only a marginal increase and a minor reduction in cycling rates respectively.

The connections between working and mobility practices were also important influences on the cycling rates and patterns observed. Kurz et al. (2014) and Hui (2013) consider the effect of dependences between practices, examining how the spatial relationship between home and the location of working practices led to dependencies for particular mobility practices. Dependencies between mobility and working practices were variability affected during the COVID-19 pandemic; for example, Hong et al. (2021) and Buehler and Pucher (2021b) both note that commuter cycling reduced in response to changing working practices. However, many individuals were unable to shift to home-working during the pandemic. For example, Fischer et al. (2022) found changes to commuter cycling flows were spatially varied; for example, observing increased flows to and from hospitals, reflecting the modal shift of medical staff to cycling. Changes to other lifestyle practices also impacted mobility patterns (Greene et al., 2022); for example, De Vos (2020) and Schweizer et al. (2021) both observed increases in recreational or "undirected" travel by cycle.

This paper will extend this work by providing a rich, empirically based account of cycling through the pandemic, providing insights to understand how the lesson of this disruption might be harnessed to support a longer-term modal shift towards cycling. This paper will draw from the experiences of the Liverpool City Region to examine and address these points. Before doing so the research approach will be outlined.

2. Methods

The research uses the Liverpool City Region, located within the North-West of England, as a case study. Between November 2019–2020, the proportion of the population who cycled at least once, or three times a week was 10.2% and 4.8%, respectively, which is slightly below the English averages of 11% and 5.3% (DfT, 2021). The region is made up of six local authority areas (see **Table 1**), encompassing a range of socio-economic diversity, including many areas of significant deprivation within urban and suburban neighbourhoods, alongside more prosperous suburbs and semi-rural areas (MHCLG, 2020). The population is concentrated within Birkenhead on the Wirral, and the City of Liverpool itself, which expands into the surrounding boroughs of Knowsley and Sefton. As argued by Buck and Nurse (2021), the city of Liverpool at the centre of the metropolitan area represents an "ordinary city" in cycling terms, lacking an established cycling culture with a limited provision of cycling infrastructure, which is reflected within the aforementioned cycling participation rates.

Whilst the provision of cycling infrastructure has previously been characterised as lagging beyond other core UK cities and European comparators (Nurse and North, 2013), the Liverpool City Region Combined Authority (LCRCA) has plans to deliver a 600km network of cycling and walking routes across the region in the next decade, which is summarised within its Local Cycling and Walking Infrastructure Plan (LCRCA, 2019). This plan forms part of LCRCA's (2019, p50) wider Transport Strategy to encourage a modal shift towards low-carbon modes of transport, with an aspiration to "[…] use all relevant Combined Authority plans, policies, powers and programmes to create high-quality environments that encourage active travel". In the context of the pandemic, and in line with this aspiration, the LCRCA was awarded £1.97m of funding from the Department of Transport in July 2020, which provided funding to install 23km of "pop-up" cycling and walking routes, bicycle storage, and various traffic-calming measures (see LCRCA, 2020, for additional details). A second, larger payment of £7.9m was awarded for the longer-term implementation of schemes identified within the LCWIP, though the implementation of such schemes has not yet begun.

Participants were recruited via advertisements placed across local social media forums between February and March 2021; these advertisements led to the recruitment of 30 participants (named P1–P30 in the paper); and all were residents within the Liverpool City Region (see **Table 2** for more information). The purposeful sampling approach targeted the recruitment of individuals with a diversity of cycling experience. Approximately half of the participants had not cycled in the previous 10 years, some cycled for the first time during the pandemic, the remainder had cycled at least once a week before the pandemic. This approach ensured that two distinct but equally important experiences were captured, the first was an ability to compare their perceptions and experiences of cycling prior to, and after

Table 1: Summary of local authorities in Merseyside. Data from: ONS (2022).

Local Authority	Population	Population Density
Liverpool	486,088	4,676/km²
Knowsley	154,517	1,787/km²
Sefton	279,233	1,823/km²
St. Helens	183,248	1,344/km²
Wirral	320,199	2,039/km²
Halton	128,478	1,624/km²

Table 2: Summary of participants (cyclists).

Participant Number	Gender	Existing/Returning/New Cyclist	Participant Number	Gender	Existing/Returning/ New Cyclist
P1	Male	Existing	P16	Male	New
P2	Male	New	P17	Male	Returning
P3	Female	New	P18	Female	New
P4	Male	Returning	P19	Female	New
P5	Female	Returning	P20	Male	Returning
P6	Female	New	P21	Female	Existing
P7	Male	Existing	P22	Male	Existing
P8	Male	Existing	P23	Male	New
P9	Female	Returning	P24	Male	New
P10	Male	New	P25	Female	Returning
P11	Male	New	P26	Male	Existing
P12	Female	Existing	P27	Female	Returning
P13	Male	Existing	P28	Male	New
P14	Female	New	P29	Female	Existing
P15	Male	New	P30	Male	Returning

Table 3: Summary of participants (cycle shops).

Participant Number	Local Authority
PS1	Liverpool
PS2	Wirral
PS3	Wirral
PS4	Halton
PS5	Knowsley
PS6	St. Helens
PS7	Sefton
PS8	Liverpool

the pandemic. Others were able to outline how the various aspects of disruption relating to COVID-19 influenced their decision to begin cycling during this period. These insights were supported by a separate series of interviews with local cycle shops named PS1–PS8 (see **Table 3** for more details).

The interviews were undertaken in two phases, via telephone or teleconferencing software in December 2020 (cycle shop owner interviews) and March–April 2021 (resident interviews). The interviews were between 16–72 minutes and were all conducted by the author. The study was approved by the University of Liverpool ethics committee, and the participants provided consent to take part in this study, including the recording and transcription of their

interviews. All audio and textual data were fully anonymised and no incentives were offered to take part in the research.

The initial lockdown restrictions were implemented within the UK on 23rd March 2020, which consisted of a "stay at home" order, alongside the closure of all leisure, hospitality and non-essential retail businesses. However, an hour of outdoor exercise was permitted each day (see House of Commons, 2021, for further details). This was gradually eased from May 2020, with increased freedoms; however, by November 2020 a number of restrictions returned, and in January 2021 restrictions were similar to the initial restrictions enforced in March 2020. Therefore, when the resident interviews occurred, these restrictions were in the process of being gradually eased in stages, ahead of the removal of all legal restrictions in July 2021 (see House of Commons, 2021, for further details).

All the interviews followed a semi-structured format, providing the flexibility to explore particular issues in greater detail, whilst retaining consistency (King et al., 2018). A topic guide was followed; in each case the participants were asked to reflect upon the changes prior to and after late March 2020 (i.e., the period where COVID-19-related restrictions were first enforced in England). The questions centred upon the following issues: changes to their working and lifestyle in response to the pandemic, their experiences, and perceptions in relation to cycling and their intentions to continue cycling regularly (or not). The interviews with cycle shop owners focused on changing consumer behaviour concerning cycle repairs and purchasing and their perceptions of factors that encouraged many to cycle across the Liverpool City Region during the period of the pandemic. An inductive coding approach was followed, using NVIVO to develop a series of codes from the textual data; these were then analysed and synthesised into a series of themes (Saldaña, 2015). These themes will now be explored in detail in the following section.

3. Findings

There was considerable attention paid to the implementation of various types of temporary infrastructure to support cycling during the COVID-19 pandemic within the media and among researchers. This paper identified these interventions, alongside the effects of a reduction in the volume of motorised traffic on the road and disruptions to everyday working and personal routines, as important factors which drove greater participation in cycling. Each of these themes will be explored in the following section before the paper considers the implications of these findings within the discussion.

3.1. Temporary infrastructure

Despite the prominence of temporary infrastructure in the media (e.g., Morton, 2020), this tended to be underplayed by our participants. In common with their complaints of permanent infrastructure, the effects of the temporary interventions were seen to be spatially limited and reflective of a piecemeal approach to cycling infrastructure provisioning in the Liverpool City Region. That said, those who did make use of the lanes felt they did represent a substantive improvement to the "painted line" cycle lanes that many of the temporary interventions were installed upon. This was because the temporary infrastructure now provided physical separation from other road users, which fostered perceptions of safety as well as providing greater legitimacy to cyclists on the roads. However, in the months following the implementation of the temporary lanes, they began to be compromised by poor maintenance (i.e., a lack of street cleaning) and damage to the plastic "wands" which demarked the cycle lane from the main carriageway. This meant that parked cars could block the lanes, forcing cyclists to meander out into the main carriageway, which for many felt like a dangerous manoeuvre to undertake. However, the participants did recognise the challenges posed

by the necessity of the rapid implementation of the temporary infrastructure. The prevailing view of participants was suitably summarised by PS5, "it's not perfect by any means, but it's a lot better than what we've ever had before."

A secondary role of the pop-up lanes was also evident: even if the lanes were not located conveniently for individuals, they remained a physical sign, as stated by PS7, that "infrastructure is changing and they've obviously heard that Liverpool was playing their part [...] at last the pennies dropped and it is going to improve." P26 also pointed out that he felt the provision of the lanes was not mainly aimed at existing cyclists, rather they acted as a means to encourage those who do not cycle to try it, in a safer environment. Both comments illustrate that perceptions of the safety of cycling can be altered through the provision of cycling infrastructure in the city, even if this is not directly utilised or experienced by an individual.

While the fieldwork took place ahead of a removal of a temporary pop-up cycle lane in West Derby Road (see Thorp, 2021a), this secondary role of infrastructure suggests why the complaints and public outcry (Thorp, 2021b) were so significant. It suggests that the removal not only meant the practical loss of the lanes for local residents and workers but also represented a negative signal for (would-be) cyclists, indicating that Liverpool City Council was rowing back upon the physical commitments and positive statements regarding cycling made during the COVID-19 pandemic.

3.2. Reductions in traffic volumes

The major reduction in traffic volumes (DfT, 2021) was seen by our participants to have a more significant impact on the cycling environment than the aforementioned "pop-up" infrastructure. This change can be conceptualised as an alteration in competition between mobilities; this study indicates that a key beneficiary of this change was cycling. The disruption to usual traffic flows was viewed by some participants as a unique opportunity to develop their cycling skills without the usual dangers posed by navigating busy roads. There was a recognition that this opportunity was time-limited, and some pointed out that they had long considered starting cycling, but they had been put off by a perceived danger of competing with other road users. With this barrier removed, they were keen to seize the opportunity before traffic volumes rebounded: "It was really quiet on the roads, which made a massive, massive difference, just being able to learn what it was like being on the road, how to negotiate the roads, how to do junctions, the gears" (P28).

The disruption of the pandemic, therefore, reduced the dominance of the urban environment by motor vehicles, which then reduced the perceived dangers and confidence required to begin cycling. This change, therefore, created what Dunning and Nurse (2020, p1) termed a "surprising availability of cycling and walking infrastructure". This was primarily additional road space, which was not dedicated to cyclists, alongside the piecemeal provision of temporary cycling infrastructure. These changes provided the newly recruited cyclists time and space to build up the skills and confidence which might then enable them to continue cycling even when traffic flows rebounded to pre-pandemic levels.

Those who cycled before the pandemic felt the disruption to traffic flows radically changed their experiences, with feelings of anxiety replaced with an altogether more relaxed experience, which will be described in more detail in the following section. For others, it was their first experience of cycling on the roads, since previously they confined themselves to the safety of the pavement or off-road routes.

When participants were asked to recall how the impact of changing traffic flows changed following the removal of the more stringent lockdown restrictions in the UK (from May 2020), they described that the positive effects of disruption quickly were lost as volumes of traffic quickly rebounded towards "normal" levels. In response to this, there was heterogeneity in

the evolution of cycling behaviour. One group of participants felt the experience of cycling in relatively conductive conditions, that is, without high volumes of traffic, provided them with the confidence and skills to continue cycling, even considering the dangers posed by cycling on busy, car-dominated roads. Another group of participants were less enthusiastic, remarking that the rebound in traffic volumes quickly discouraged them from cycling regularly. They felt this change meant that they were now limited to a smaller number of routes, such as off-road routes or roads with dedicated cycling infrastructure, or they avoided cycling during the "peak times" in traffic volumes. Both self-imposed limits would have an adverse effect on the ability to cycle for non-recreational purposes such as commuting to their workplace.

3.3. Changes in working practices

In response to the pandemic, the UK Government, in common with many Governments, temporarily restricted almost all economic, social, sporting, and leisure practices to a varied extent between March 2020 and July 2021 (Cabinet Office, 2020). This enforced many changes to everyday life and routines, such changes that interacted with cycling, given the connections and competition between cycling and various other lifestyle and working practices.

Changes to participants' working practices were a central theme of discussion. There were significant differences in the experiences of participants, depending upon their sector of work, and the corresponding ability and/or necessity to shift their working practices to the home. This led to diversity in how disruption impacted their mobility demands, with the guidance to "work from home" resulting in the spatial relocation of working practices and the severing of the dependencies between mobility and working practices, in common with participants who temporarily ceased working.

In contrast to much of our discussions, which pointed towards the multiple factors that encouraged greater rates of cycling, the loss of this dependency meant that some participants reduced their time cycling. Beyond meeting the need to travel to work, there were additional relationships between working practices and cycling, as P26 described: "The lunchtime cycle, I would normally extend that, do a long cycle, call in at home for lunch, then cycle back to work. Because I wasn't doing that, I put on about a stone and a half in weight by late August, so the commute was not the exercise, but it was the catalyst." The dependence between cycling and work was previously an important motivating factor that catalysed additional time cycling for exercise, such as by extending or deviating from the quickest route home. The loss of these dependencies, therefore, meant that some participants also spent less time cycling for leisure purposes.

Others lamented the loss of their cycle commute, which was an opportunity to "freshen up" ahead of work or to relax and "de-stress" after working, which they identified as part of the wider challenges of re-locating working practices to within the home. Here, the loss of a cycle commute was evidence of how divides between professional and home life were weakened through the disruption to working practices. In recognition of this, a participant described how a "fake commute" before work helped to manage this change, highlighting the important interactions between mobility and working practices. In contrast, the disruption of the dependencies between these practices was viewed positively by several participants, particularly for those who devoted significant periods of time commuting by motor vehicle, which they associated with stress and a loss of personal time. Instead, this formed part of a wider "slowing down" of everyday life, which left additional time to devote to a range of leisure practices, such as cycling.

In contrast, several participants continued to work physically at a workplace or had caring commitments, but lacked access to a private vehicle; for these individuals the dependencies between cycling and these practices strengthened significantly. They described that

government guidance to avoid public transport (Cabinet Office, 2020) and fears of COVID-19 infection meant that they chose to avoid public transport to access their workplace as well as other amenities. Previously, a choice to cycle was a voluntary decision or something they had not considered – it now became essential, illustrating how the disruption strengthened the dependencies between cycling and other practices. In recognition of this, and reflecting the severe limitations in the availability of cycles for sale, several local cycle shops described how they provided free-cycle loan schemes to healthcare professionals and other essential workers. This indicates the vital role that cycling shops played in supporting resilience within the mobility sector.

3.4. Changes in lifestyle practices

The COVID-19 regulations within the UK meant that cycling became one of the few activities for which it was permissible to leave the home. Many of our participants recounted how their favoured leisure activity was outlawed, for some this was a physical activity such as exercising at the gym or participating in multi-person sports such as football and tennis. Others spoke of the loss of the opportunity to socialise with friends or visit entertainment venues. Regardless of the activity, many sought out a replacement to fill their spare time; therefore the reduction in competition for an individual's time and energy meant that participation in cycling rose in response to the disruption of many other competing leisure practices.

Participants explained how, in different ways, the disruption to everyday life alongside the anxieties of the pandemic led to feelings of increased stress, which was often accompanied by negative changes in their daily routines. A common example was the loss of regular exercise practices and greater consumption of food and alcohol, leading to an increase in weight and a loss of fitness. Furthermore, and especially for those who were clinically vulnerable, there was a need to adapt to a greater level of social isolation and confinement within the home. Many of our participants described how this contributed to a negative impact on physical health and well-being, especially for those who were living alone.

In response, many of the participants begin to cycle, sometimes for the first time, perhaps because it was one of a limited number of options to replace their usual leisure practices as well as its suitability in combating identified declines in physical health and wellbeing:

> ...I realised I had to really change my lifestyle quite a bit and get healthier in January, I started cycling not just going out once or twice a week. I started going out, well every night, every other night, starting off in 5 miles at first, then pushing it more and more every day (P10).

They and other participants desired to improve their physical health but quickly began to recognise the many and varied benefits provided by cycling. Here, many echoed the sentiment of P30: "when I couldn't get out I was a bit fed up with that. I'm 63, but in the end it was starting to get to me, all this staying in. So the cycling really was a relief." This sense of "relief" offered by cycling was credited to the corporeal experience of cycling (Sheller and Urry, 2006), which provided an opportunity to appreciate the surroundings they were travelling through. Others cite noticing the changing of the seasons, hearing birdsong, or breathing the fresh sea air, and for some the simple, repetitive motions of cycling were likened to a form of meditation.

Lockdown measures also heavily limited the spatial extent of travel and exercise, meaning participants were forced to relocate practices locally in accordance with the measures. Participants described their exploration and (re)-discovery via cycling of their local green spaces, nature reserves, coastal promenades, and the particularly novel, deserted city-centre

streets. P10 described that as not only an exploration of physical space but represented an exploration of their memories, describing cycling as "like a time machine, re-exploring my life, reconnecting with the places that all these things happened." Collectively, the experiences described by our participants contributed towards developing a relaxed and mindful state, providing a time for contemplation and an escape from the everyday stresses and anxieties of COVID-19.

Several participants used cycling as an opportunity to facilitate some social contact, many of our participants, like P16, remarked that cycling together had a low risk of COVID-19 transmission and therefore felt comfortable doing so: "it was like, a community, as a couple of us got a bike together, so you know [P18], we all got a bike at the same time, it was nice to be able to meet up with people outdoors, and have a goal for the day, and have a social activity." Therefore cycling played an important role in facilitating a shared, social experience, providing a rare escape from the solitary nature of everyday life during the pandemic. It was also evident that the social aspect of cycling was important to those who recently began to cycle, since it supported building confidence in cycling, with social connections providing an opportunity to share skills and encouragement.

Overall, it appeared that the varied nature of benefits derived from cycling meant it was well placed to meet the desire of individuals to emulate aspects of their "pre-COVID" lifestyle, particularly physical exercise, relaxation and socialising as well as simply filling spare time. As a result, it was clear that participation in cycling helped to support feelings of well-being and life satisfaction, even in the challenging circumstances of COVID-19.

4. Discussion

4.1. Reflections upon disruption, COVID-19, and cycling

The COVID-19 pandemic had a disruptive effect on many aspects of society (Greene et al., 2022). This study focused on how and why these changes affected the propensity of an individual to cycle in the Liverpool City Region, UK. Events of disruption can provide important opportunities for researchers and policy-makers to explore alternative arrangements and practices, as illustrated by Rinkinen, Shove, and Marsden (2020) and Marsen and Docherty (2013). The COVID-19 pandemic was an example of a rare, very high-magnitude event of disruption. In particular, and as set out above, lifestyle and working practices saw significant changes, impacting the opportunities and willingness of an individual to cycle. Other changes related to the response of governments to the mobility challenges were introduced by the pandemic, such as the implementation of temporary infrastructures (Lovelace et al., 2020; Nikitas et al., 2021).

Like Boons et al. (2020), this research used this period as a "natural experiment", since it represented a rare opportunity to observe how a particular aspect of society might be re-imagined and reconfigured to facilitate a transition towards a more sustainable world. This article considered how the disruption of COVID-19 led to many inter-connected changes, which collectively broaden the uptake of cycling. By doing so, it can help to identify the nature and scope of change that might be required to facilitate a longer-term modal shift to cycling, especially in localities where cycling currently occupies a marginal modal share.

The temporary infrastructure, largely comprised of temporary traffic "wands" or "cones" within the Liverpool City Region, were not raised by participants as a major factor in supporting the take-up of cycling, in contrast to the prominence in popular media (e.g., Morton, 2020). That said, it was clear that the highly visible changes were important in raising the prominence of active travel, illustrating the symbolic role of cycling infrastructure as raised by Buck and Nurse (2021).

The evidence set out surrounding temporary infrastructure aligns with Hong et al. (2020), who found the segregated cycling routes in Glasgow, UK, did not see an increase in cycling rates during the pandemic. This is despite extensive evidence which linked perceptions of safety and uplifts in cycling to the provision of dedicated cycling infrastructure (Buehler and Pucher, 2021b; Lorenc et al., 2008), including studies during the pandemic (Fischer et al., 2022; Kraus and Koch, 2021).

Instead, the testimony in this study placed a greater emphasis on the effects of reductions in traffic volumes, rather than the impact of temporary infrastructure. This may be due to the spatially limited nature of the lanes, in contrast to a roughly uniform reduction in traffic volumes across the City Region (DfT, 2021). This change meant that cyclists no longer had to compete with the dangers posed within car-dominated environments (Cupples and Ridley, 2008). Given the evidence of the conflicts between auto-mobility and velo-mobility, in previous "pre-pandemic" studies (e.g., Buck and Nurse, 2021; McKenna and Whatling, 2007), it is not surprising that participants regularly cited the reduction in traffic volume as being an important factor in their decision to begin cycling or to cycle more often. Several other studies examining changes in cycling patterns during the pandemic found similar patterns (e.g., Büchel et al., 2022; Gladwin and Duncan, 2022), with Lock (2020) finding greater proportions of responses citing reduced traffic compared to new temporary cycling infrastructures as being important in supporting individuals taking up cycling in Sydney.

Another key aspect of disruption related to changes in working and lifestyle practices during the COVID-19 pandemic. These changes were diverse among our participants, and as a result the impacts upon their propensity to cycle also differed. Hui (2013) writes that the demand for travel by certain modes and to certain destinations is driven by the spatial ordering and organisation of practices. As was observed in this study, the pandemic disrupted these relationships, aligning with the work of Hong et al. (2021) and Buehler and Pucher (2021b), who both note that commuter cycling reduced in response to changing working practices. For some in our studies, this had a negative impact on their well-being, echoing the psychological challenges described by Risi et al. (2021), which were imposed by the blurring of professional and home life. In our work, it was evident that the loss of a cycle commute was an example of how this boundary was weakened. Though for others, dependencies on cycling increased, something highlighted by Fischer et al. (2020), who observed an increase in commuter traffic flows nearby medical facilities.

As was raised in our study, some sought to replace the loss of their usual cycle to work with a "fake commute"; similarly the loss of other sporting, social, and lifestyle practices were replaced by cycling by many of the participants in this study. Most commonly raised in our study was the loss of many regular exercise practices, which was also reported by Bu et al. (2021) and Greene et al. (2022). This meant that cycling was well placed to replace the loss of activities such as team sports or working out in indoor gyms. Indeed De Vos (2020) and Schweizer et al. (2021) also observed increases in recreational or "undirected" travel by cycle. De Haas et al. (2020) and Buehler and Pucher (2021b) also found that the increases in cycling rates during the pandemic period were largely made up of an increase in the proportion of leisure trips.

The gradual easing of COVID related restrictions created a differential effect upon different aspects of everyday life, meaning that the extent and permanence of the changes discussed differed between individuals (Gershuny et al., 2021). Whilst certain job roles required a full return to the workplace, others have followed a hybrid or fully home-working approach (Mark et al., 2022). Each has a different effect upon the requirements to travel, with some individuals perhaps retaining certain aspects of their COVID lifestyle, such as "fake commutes", and

others returning to their pre-COVID routine, such as cycle commuting regularly. For others, the reinstatement of leisure practices, such as team sports or working out in indoor gyms, may mean that the adaption of everyday routines which led to the take-up of cycling, may be temporary, and instead, they may revert to their pre-COVID activities.

The reduction in traffic volume meant that there was greater safety, and in some cases, the relative tranquillity provided new opportunities for exploration and relaxation whilst cycling. This indicates the pathways by which cycling can improve mental well-being (Anokye et al., 2012), which provided a psychological buffering effect during the pandemic (Mutz et al., 2020).

4.2. Reflections for facilitating a long-term modal shift towards cycling

The research approach was effective in explaining the increased participation in cycling during the pandemic. The disruption caused by the pandemic usefully revealed some of the changes that may be required to broaden the recruitment towards cycling in the future. In this way, the approach of this study, which included a comparison between the situation prior to and following the disruption of the pandemic, has parallels with research that seeks to draw out lessons from "exemplar" cycling cities such as Amsterdam and Copenhagen (e.g., Larsen, 2017; Pucher and Buehler, 2008). In the Liverpool City Region, it was clear that the busy, car-dominated environment and the lack of provision of dedicated cycling infrastructure had previously limited the take-up of cycling, a conclusion which is shared within survey data of Liverpool City Region's residents (Sustrans, 2019). The reduction in traffic flow and the limited implementation of temporary cycling infrastructures helped to alter this, alongside changes to the working and leisure practices of individuals. The paper now turns to how the lessons learnt from temporary disruption can be harnessed and identifies what policymakers can implement to capitalise upon this period to better support a longer-term modal shift to cycling.

Sheldrick et al., (2017) highlight the challenges of transferring lessons of cycling policy and interventions in such cities to other locations without critically considering the contextual factors which led to success. In light of this, there must be caution when considering how to apply the findings and recommendations from this study to other localities. That said, two factors may support the wider application of the lessons drawn during the "natural experiment" of COVID-19, thereby providing more convincing findings and recommendations for policy-makers in a variety of geographical locations. Firstly, many urban areas in the UK and beyond are in a similar situation to Liverpool City Region, with a marginal modal share and limited dedicated infrastructure, rather than representing the less common, exemplar cycling city status. Secondly, even if the conditions of COVID-19 were highly circumstantial, identifying the factors that can be emulated post-pandemic may be more successful than relying upon policy transfer from exemplar localities. Yet, in doing so it is important to consider the breadth and magnitude of change that COVID-19 brought to almost all areas of life. As a result, it is challenging to identify a "silver bullet" intervention that could emulate the conditions which made cycling so attractive during this period. For example, emphasis was placed upon the significance of reduced traffic flow, which reduced competition for road space; however, without the temporary reduction in competition for individual time (another factor identified as significant in supporting recruitment to cycling), this may not have resulted in such a boost towards recruitment to cycling.

Our participants were enthusiastic about their experience of cycling during this period, and it was clear that without such disruption many would have never begun to cycle. However, it is important to recognise what fundamental and wide-ranging changes in an individual's

personal and working lives and traffic flow occurred to create the conditions which were so conducive to cycling. The paper, therefore, helps to illustrate the level of disruption which proceeded the uplift in participation in cycling, and barring the need for similar "lockdown" measures in the future, it is highly unlikely that such change would occur again. Therefore, the central objective for policy-makers is to consider how such conditions might be emulated to some extent in "normal times".

There are several conditions which, if met, can help to prevent a practice such as cycling from "bounding back" to a previous state (Boons et al., 2020). In particular, relevant to this study is the learning of new practices to which individuals have become positively attached to, the provision of infrastructure and regulation discouraging less-sustainable transportation practices. These will be now be considered in greater detail to identify the potential to foster longer-term participation in cycling in the Liverpool City Region and beyond.

The study found that the skills learnt, alongside the positive experiences and benefits that newly recruited cyclists drew from cycling during the period of the pandemic, may help to support a longer-term modal shift to cycling within the City Region. Yet, with several temporary infrastructure schemes already removed (Thorp, 2021a), rather than transitioning into permanent provision, there are signs that the necessary provisioning of infrastructure to continue supporting a modal shift towards cycling has not been forthcoming. The findings also suggest that the rebounding of traffic to near "normal levels" had already discouraged many newly recruited cyclists from continuing to cycle, with others temporarily and/or spatially limiting cycling to where and when they deemed it is safe enough. This significantly limits the potential for modal shift, particularly for utility cycling such as commuting to work. This expands the conclusions of Musselwhite et al. (2021) and others who suggest that in many localities there has been a failure to implement the necessary physical measures and mobility strategies to sustain the temporary uplift in cycling rates, and like this paper, they highlight the removal of temporary cycle lanes as reflective of this trend. This paper, therefore, argues that at least at this point in time, the disruption of the COVID-19 pandemic appears an opportunity lost, rather than a "turning point in active travel" (Nurse and Dunning, 2020, p1) in the Liverpool City Region.

Whilst the more conducive conditions observed during the pandemic may be lost, there are lessons that can be drawn from this period to catalyse a future modal shift towards cycling. Clearly, certain aspects of the pandemic are undesirable to emulate (i.e., the loss of certain leisure practices), and therefore changes in this area offer little to the policy-makers. However, it was the reduction in competition for road space that was also identified to be crucial in supporting additional recruitment towards cycling. Therefore, the paper suggests that policy-makers must focus on two complementary objectives, expanding the conclusions of other pandemic studies (e.g., Buehler and Pucher, 2021b; Nikitas et al., 2021). These are the reduction in the competition for road space between velo- and auto-mobility, and secondly, to increase the provision of dedicated materials for cycling, such as permanent cycle lanes and modal filters.

The experiences outlined in the findings of this study and elsewhere indicate that interventions should seek to disrupt existing mobility arrangements by providing dedicated infrastructure, including but not limited to cycle lanes. Secondly, they should disrupt these arrangements by limiting the access of private motor vehicles within certain places and spaces of the urban environment, such as through low-traffic neighbourhoods, and removal of car parking spaces. The evidence from this study indicates that such disruption to existing, unsustainable mobility arrangements must be implemented if the uplift in cycle participation observed during the pandemic is to be replicated.

5. Conclusion

This study used the "natural experiment" of the COVID-19 pandemic, which radically disrupted many areas of everyday life, to explore the effect of this disruption upon cycling through a series of semi-structured interviews with residents and cycle shop owners in the Liverpool City Region, UK. It sought out to explore why participation in cycling rose, drawing new individuals as well as existing cyclists to devote more time to cycling. In doing so, the paper reflects how policy-makers might learn from this period, to emulate these conditions in a bid to support a longer-term modal shift towards cycling. It illustrates the impact of changing dependencies between working and mobility practices and of reduced competition from alternative leisure practices, alongside the impact of reduced competition for road space (due to reduced traffic flows). It was evident that the latter, supported by the provision of temporary cycling infrastructure, helped to reduce the perceived skills and confidence required to cycle. Many individuals identified a range of positive experiences and benefits of cycling, providing them with additional incentives to continue cycling.

Yet, as traffic re-bounded to "normal levels" it became clear that at least in the short-term there was a failure to fully capitalise upon this period of disruption. Although the findings do point towards the significance of outlawing many leisure practices in increasing cycling rates, there are several infrastructure interventions which can be made to imitate the conditions observed in our study. The overall implications of this research are clear: a radical change in the materiality of the urban environment alongside a paradigm shift in traffic management must occur if policy-makers wish to capitalise upon the disruption of the COVID-19 pandemic and to drive a transition to more sustainable urban mobility systems.

Competing Interests

The authors have no competing interests to declare.

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