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Scaling up cycling or replacing driving? Triggers and trajectories of bike–train uptake in the Randstad area

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Abstract
The combined use of the bicycle and the train in the Netherlands has risen steadily over the past decade. However, little is yet known about the underlying processes driving the growth of bike–train use in the Netherlands. Are new bike–train trips replacing car trips, or are they primarily an extension of existing train travel and cycling practices? The present study investigates this question by exploring the main trajectories of bike–train uptake in the Randstad area. Following a mobility biographies approach, our study seeks to identify the triggers or "key events" which lead to the uptake of bike–train use, and explores their relationship with existing travel behaviour. To this end, we carried out an online survey aimed at people who started commuting regularly by bike–train. Our results show that trajectories of uptake are varied, with a similar proportion of respondents starting to commute by bike–train in order to replace cycling, driving and public transport. While in some cases people shifted to bike–train on their existing commuting trip, most respondents started travelling by bike–train following a change in work or residential location. Overall, our findings suggest that most people do not start commuting by bike–train out of particular preference, but merely because they consider it provides the best available option. Nevertheless, the large proportion of respondents with access to a car suggests that the bike–train system is able to provide an attractive alternative to car-based interurban mobility.

Keywords Bike–train · Randstad · Mobility biographies · Triggers · Modal shift

Introduction

Cycling is typically considered to be an attractive transport option for distances up to 5 km for utilitarian trips, making it primarily suitable for intra-city trips (Chillón et al. 2016; Kager et al. 2016; McNeil 2011). For this reason, urban cycling environments tend to be conceptualized and studied at a neighbourhood- or city-wide scale (Muhs and Clifton

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2016; Nielsen and Skov-Petersen 2018). Medium-sized cities are often seen as the most conducive to cycling; in larger conurbations, longer trip distances mean that motorised or public transport are likely to become a more attractive transport option (Rietveld and Daniel 2004). Train travel, meanwhile, operates at a much larger spatial range, but the accessibility it provides is largely restricted to the vicinity of train stations, typically leading to a node-based form of urban development (Newman et al. 2016).

Recent research, however, suggests that the combined use of bicycle and train as part of a trip chain dramatically expands both the spatial reach of cycling *and* the door-to-door accessibility of the train (Kager et al. 2016). While the use of cycling as a feeder mode for last mile trips to and from train stations has attracted a moderate amount of research (e.g. Givoni and Rietveld 2007; Martens 2004; Rietveld 2000), it is only recently that it has been suggested that the bicycle-train combination should be understood as a distinct mode of transport in its own right. According to Kager et al. (2016), the synergy between bicycle and train leads to a hybrid form of transport which combines the spatial flexibility of cycling with the speed of train travel. Likewise, Lee, Choi and Leem (2016) argue that the combination of bicycle and train provides a way to overcome the limited spatial reach of transit-oriented development, in what they refer to as "bicycle-based transit-oriented development". In doing so, the bike–train system potentially offers both a means of "scaling up" cycling-based mobility beyond the local scale, and "optimising" regional train travel. This combination of speed and flexibility makes the bike–train combination a promising alternative to potentially replace many car trips (Kager et al. 2016; Jonkeren et al. 2018).

Given its potential to act as a potential alternative to car travel, academic research on the bicycle-train combination (and bicycle-transit more generally) has grown significantly in recent years. In a recently published article, van Mil et al. (2020) provide a valuable review of the main factors which influence bike–train use, classifying them into transit-related factors, first/last-mile factors and context. As their article documents, high quality public transport, good cycling facilities (e.g. bike lanes, bike parking at stations), and a well-developed local cycling culture are some of the key factors which are associated with high levels of bike–train use.

The character and focus of existing research on the bike–train combination, however, vary substantially between geographic settings, responding to the disparate realities of bike–train use in different contexts. In North American cities, the bicycle is primarily seen as a potential solution to first/last mile access trips to rail stations in suburban settings, which are difficult to serve by alternative means of transport (Mitra and Schofield 2019). As various studies have suggested (Boarnet et al. 2017; Zuo et al. 2020), cycling to transit can markedly improve public transport accessibility in North American cities, especially for low income and minority groups, and therefore potentially offers an effective means of increasing transit equity. Low levels of cycling and public transport use mean that the overall volume of bike–train trips in North America nonetheless remains small, even though an increasing number of American cities have implemented infrastructural and policy measures to improve bike-transit integration (Pucher and Buehler 2009). As documented by Ravensberger et al. (2018), safety concerns, lack of adequate bicycle parking, lack of comfort and personal appearance concerns remain strong barriers to increased bike–train use in a North American context.

Another setting in which the bike–train combination has attracted noticeable attention is China. Building on the country's rich cycling history, the bike–train combination is seen as a way of solving the accessibility problems associated to rapid urbanisation and providing access to growing urban rail networks (Pan et al. 2010). Among others, Zhao and Li (2017) have explored determinants of bike use to access metro stations; in addition, the rise and

prominence of bikesharing in many Chinese cities have made the combination of transit and bikesharing a topic of especial interest for researchers (e.g. Ji et al. 2017).

However, the bicycle-rail combination is by far the most developed in the Netherlands, which has the highest cycling rates in the world (Harms et al. 2014) and also possesses a highly developed rail network. For this same reason, the Netherlands has attracted the lion's share of existing research on bike–train travel. In recent years, a growing number of studies focusing on the Netherlands have provided an incipient understanding of bike–train trip patterns and user characteristics within the Dutch context (Shelat et al. 2018; Jonkeren et al. 2019). Albeit not to the same extent as in the Netherlands, the bicycle-train combination is also popular in other mature cycling countries such as Denmark: as documented in a study by Olafsson et al. (2016) in a representative sample of the Danish population, about 12% of the Danish population use cycling as a means of reaching public transport.

Despite the increasing number of available studies on bike–train use, to the best of our knowledge no study has explicitly focused on identifying the *triggers* which lead people to start travelling by bike–train. Through a retrospective longitudinal survey with people who have begun commuting by bike–train, the present paper aims to identify the main triggers and trajectories[1] of bike–train uptake in the Netherlands. This is highly relevant in an international context where many countries and cities are seeking alternatives to car-based travel, and look to the bike–train combination as a potential candidate (Krizek and Stonebraker 2011): identifying triggers of bike–train uptake can yield valuable policy recommendations as to how effectively promote bike–train use. Our research seeks to address the following three sub-questions:

1. What travel behaviours are being replaced by bike–train trips?[2]
2. What are the main triggers of bike–train uptake?
3. What is the relationship between bike–train uptake and existing travel behaviour?

By answering these questions, the present paper increases our understanding of the processes and drivers which sustain and reinforce the bike–train system. In doing so, it provides further insight into the potential of the bike–train system to provide an alternative to car-oriented patterns of regional mobility and development, both in the Netherlands and internationally. Admittedly, our results are specific to the Dutch context; given the unique characteristics of the bike–train system in the Netherlands, our findings are unlikely to be directly representative or extrapolatable to other contexts in various respect. However, their value lies precisely in the fact that they provide an insight into the characteristics and dynamics of what a *mature* bike–train system looks like. This can help other countries obtain a better understanding of the necessary physical and social environment conditions required in order to achieve widespread levels of bike–train uptake.

In the next section, we provide a short overview of the bike–train system in the Netherlands. We then present the conceptual framework used to guide our research, which draws on the "mobility biographies" approach (Müggenburg et al. 2015); this is followed by a description of our methodology. In the findings section, we present some details on

[1] By trajectories, we refer to the individual life courses (i.e. temporal sequence of events) associated to the process of bike-train uptake, not to the physical routes taken by individuals to cycle to the train station.

[2] Among the travel behaviours being replaced, we also include the possibility that no previous trip was made. In other words, we do not only look at bike-train trips which replace trips previously made by other modes, but also at newly generated bike-train trips which are in effect replacing "non-travel".

bike–train trip and respondent characteristics, and then proceed to address our sub-questions, each in a separate sub-section. We close the paper with a final discussion and conclusion, in which we elaborate on our findings and their implications.

The Dutch bicycle-train system

At present, both academic and policy interest in bicycle-train travel is heavily focused on the Netherlands: worldwide, the Netherlands is the country where the bike–train system is most advanced. This is largely attributable to the country's broader cycling culture, but also to the fact that it has a particularly well-developed, high quality train network, with frequencies of up to 10 min between main cities in the Randstad area. In addition, the (increasingly) diffuse, polycentric urban structure of the Randstad itself (Musterd, Bontje and Ostendorf 2006)—characterised by large commuter flows between its main cities and surrounding areas—also seems particularly conducive to bike–train travel (the prevalence of which might contribute to reinforce this polycentric structure in its own turn). It should be noted, however, that the predominant form of bike–train travel in the Netherlands does not involve carrying a bike on the train, but simply cycling to/from a train station and parking the bicycle in the vicinity. With the exception of foldable bikes, carrying a bike on the train is strictly is forbidden during peak hours. In addition, Dutch train users have to pay a pricy supplement (€7.50 per bike/day in 2020) to carry a bike onboard a train outside peak hours (again with the exception of foldable bikes). This is primarily intended as a dissuasive measure, as it would be practically impossible to accommodate the foreseeable number train travellers who would otherwise decide to carry their bike onboard.

Over the past few years, the number of bike–train trips in the Netherlands has risen significantly, paralleling a comparable growth in the overall number of bicycle and train trips in and between Dutch cities (Jonkeren et al. 2018). As a recent report by Netherlands Institute for Transport Policy Analysis (KiM) documents, the modal shift of cycling for access trips to train stations has increased from 36 to 44% between 2005 and 2016, while on the egress side the modal shift of cycling has increased from 10 to 14% (id. 2018). Given that train trips as a whole have grown by 24% during this period, this means a substantial increase in the absolute number of bike–train trips (id. 2018). As the authors of this report mention, probable reasons for the observed increase in bike–train trips in the Netherlands include an expanding urban population, higher mobility levels driven by economic growth, and improvements to train services. In addition, a mounting number of measures have been implemented to facilitate and stimulate bike–train trips, such as the the introduction of a nationwide bike rental system at train stations (OV-fiets[3]) that has grown rapidly since 2004 (Martens 2007, 2004). This system, owned by the Dutch Railways (NS), has a fleet of over 20,000 bicycles that are used for more than 5 million trips each year (Petzer et al. 2019; Ploeger and Oldenziel 2020). In recent years, the arrival of dockless bikesharing systems in some Dutch cities has also contributed to encourage combined bike–train trips (Ma et al. 2020).

[3] Although the OV-fiets system is often described as a bikesharing system of sorts, it is more appropriately described as a public bike rental system. In exchange for a flat daily fee, travellers can hire a bike at a train station for a period of 24 h (extendable for multiple days), which they must subsequently return at the same train station.

Furthermore, a significant amount of public investment has been dedicated in recent years to the improvement of bicycle parking at train stations, including the construction and expansion of large-scale bicycle parking facilities at train stations at major cities. By contrast, car parking in most urban train stations is scarce (building on more general policies restricting car use in city centres), making it an uncompetitive option for last mile trips to/from the train stations. As an example, the biggest multistorey bike parking in the world—with capacity for 12,500 bicycles—was opened was opened in 2019 in Utrecht train station (The Guardian 2019). Nevertheless, whether these investments in bike parking capacity should be seen primarily as a cause or an outcome of bike–train uptake is open to debate. Indeed, the main rationale for expanding bike parking capacity at train stations has been to relieve *existing* congestion: as documented by van Goeverden and Correia (2018), bike parking at most Dutch train stations suffers from chronic capacity shortages.

While all of the above reasons are likely to have contributed to the expansion of bike–train travel, the relative importance of each factor in this process has not yet been established. In particular, it remains unclear whether the increase in bike–train trips is primarily the result of new trips being made (e.g. due to residential relocation or a new job), or rather the result of a modal shift from other transport modes. By exploring the main triggers and trajectories of bike–train uptake, the present paper contributes to shed some light on the driving processes behind the ongoing growth of bike–train travel in the Netherlands.

Conceptual framework

Our study chooses to look at the process of bike–train uptake through the lens of the "mobility biographies" approach (Müggenburg et al. 2015). Although this field remains diverse, it is united by its emphasis on understanding longitudinal change in travel behaviour from the perspective of individual life courses, often with the underlying aim of identifying interventions which might lead towards a shift towards more sustainable transport. Acknowledging the centrality of unreflective habits in sustaining travel behaviours (Schwanen et al. 2012), the mobility biographies approach recognises that changes in travel behaviour are unlikely to be driven by self-induced reflection alone; instead, they are more likely to be the result of "key events" or interventions which prompt a reconsideration of everyday mobility choices (Chatterjee et al. 2013; Klinger and Lanzendorf 2016; Müggenburg et al. 2015). Examples of such events or triggers include residential or workplace relocation, important biographical events (e.g. marriage, childbirth), or interventions to the transport system (e.g. new transport infrastructure, changes in parking policy). Although many studies within the mobility biographies approach do not focus on a specific transport mode, a couple of existing studies focus specifically on cycling: a well-cited study by Chatterjee et al. (2013) sought to identify triggers for changes in cycling behaviour in England, while a more recent by Janke and Handy (2019) explored the effect of life course events on cycling attitutes and behaviour in Davis, California. By focusing a new hybrid mode—the bike–train combination—which has not previously been studied from this perspective, the present study also provides a meaningful contribution to the mobility biographies literature.

Given this emphasis on triggers or "key events", the mobility biographies approach provided a logical choice of framework to guide our study. Another benefit of this approach is its strong interdisciplinarity, which makes it possible to consider interactions between various factors and influences across various domains (e.g. spatial, social, individual). As

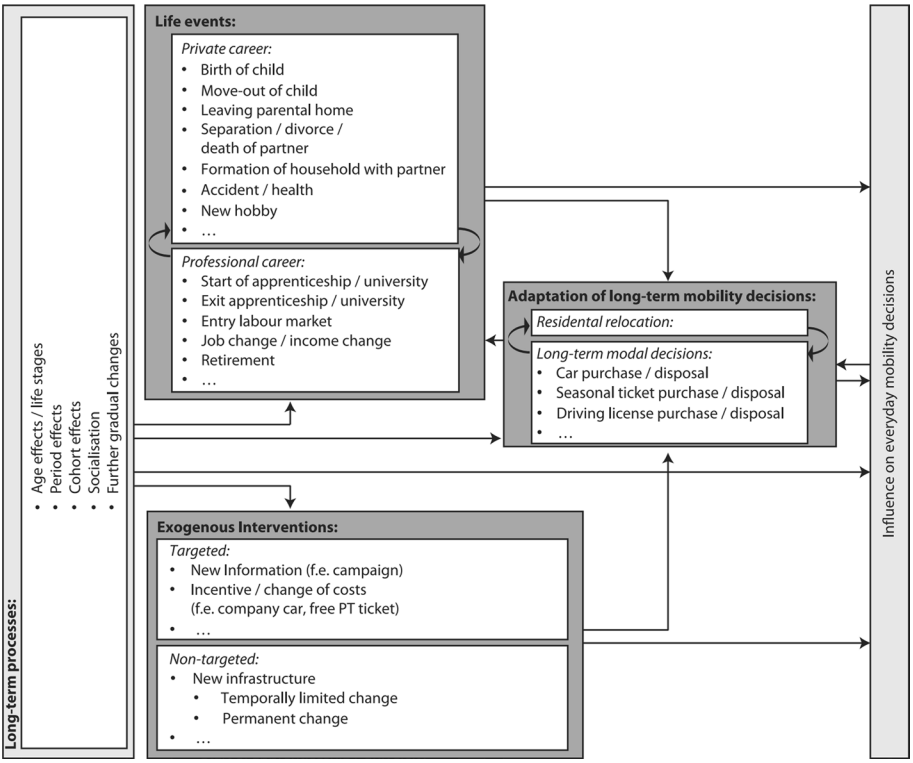

Fig. 1 Theoretical framework: interaction of long-term processes, life events, interventions and long-term decisions with daily mobility decisions (from Müggenburg et al. 2015)

Müggenburg et al. (2015) note, "drawing and relying on findings from sociology, psychology and geography, it [the mobility biographies approach] allows for an integrated assessment of spatial contexts and accessibility, interacting with social, individual, and subjective factors to analyse and understand the evolvement of travel behaviour change over time" (p. 152).

Our study is guided by the theoretical framework proposed by Müggenburg et al. (2015), displayed in Fig. 1. This framework distinguishes between four different types of triggers: (1) life events, (2) adaptations in long-term mobility decisions, (3) exogenous interventions, and (4) long-term processes (i.e. gradual changes which cannot be considered as a single event). Importantly, the framework assumes that these different triggers are often interrelated, with key events in one category often being caused or leading to another event (e.g. childbirth leading to a residential relocation). Based on this theoretical framework, we distilled a list of potential triggers of bike–train uptake, displayed in Table 1. The triggers considered largely derive from the review by Müggenburg et al. (2015), but some of them are also based on other references focusing on triggers of change in transport behaviour (van Wee et al. 2019), and cycling behaviour in particular (Chatterjee et al. 2013). It is important to note that the triggers considered were adapted to the specific characteristics of the bicycle-train mode and the findings from the existing bike–train literature (e.g. Martens 2007; van Mil et al. 2020). For example, it is well-known that getting a driving license often leads to changes in travel behaviour,

Table 1 Potential triggers of bike–train uptake (based on Chatterjee et al. 2013; Müggenburg et al. 2015; van Wee et al. 2019)

Categories	Potential triggers
1. Life events	
a. Professional career	Changes in work or study trajectory (e.g. entering labour market, start of university, change of employer, job relocation)
	Change in employment/study hours (e.g. full-time/part-time)
b. Private career	Change in household composition
	Children starting/changing/stopping school
	Traffic accident
	Health-related event
	Reduction in household income
2. Adaptation of long-term mobility decisions	
a. Residential relocation	Residential relocation
	Purchase of bicycle (especially foldable/e-bike)
	Purchase of train season ticket
	Disposal of private car
3. Exogenous interventions	
a. Targeted	Improved train services (e.g. frequency, reliability, comfort)
	Improved bicycle parking at stations
	Increased OV-fiets availability
	Introduction of Swapfiets/bikesharing system
	Improved cycling infrastructure
b. Non-targeted	Reduced availability/increased cost of car parking
	Other disruptive events (e.g. road closure, strike, flood)
	Change in workplace travel incentives
	Increased carsharing available
Other processes	
a. Socialisation	Peer effects (work/family/friends/other commuters)
b. Landscape trends	Increasing traffic congestion
	"Healthy living" societal trend
	Increasing environmental awareness
c. Attitude changes	Attitude changes (e.g. growing dissatisfaction with PT/car)

but there is no reason to think that it would lead to an increase in bike–train use; accordingly, we have not considered it in our study. Nevertheless, our study also allowed for the bottom-up identification of potential additional triggers through the inclusion of open questions in the survey.

Method

Our main research method consisted in a structured online survey targeting people who had begun commuting at least once a week by bike–train within the past 5 years. People who had started commuting by bike–train more than 5 years ago were excluded, as we deemed they might no longer be able to faithfully recollect their memories from that time. As a means of narrowing our sample, we restricted our focus to the Randstad area,[4] because it is the region of the Netherlands in which the bike–train system is the most clearly developed. With a dense train network and high levels of interurban mobility, the polycentric conurbation of the Randstad includes the four largest cities in the Netherlands, making it a logical choice for our study. Respondents were recruited from the TNS NIPObase panel, a database of approximately 200,000 individuals which is broadly representative of the Dutch population.[5] For this, we collaborated with Kantar, a research company which is frequently commissioned by public authorities in the Netherlands for work on surveys and related projects. The TNS NIPObase panel has already been used for various academic studies in the past, including a study exploring carsharing in the Netherlands (Nijland and Meerkerk 2017). Our survey had an approximate length of 15–20 min, and was based on a relatively complex logic involving a number of different pathways which made it possible to tailor questions to different respondents. While most of the questions were closed (albeit including an open option), we also included a couple of completely open questions. These questions were not intended as a main survey output, but as a means of triangulating the results from the closed questions, as well as identifying possible issues or options which might have not been considered. In the "Appendix", we provide a short outline of the structure of the survey.

In addition, six preliminary in-depth interviews were carried out before the survey, each of which lasted approximately 30 min. The main aim of these interviews was to help refine the survey questions, but they also proved valuable in providing a richer qualitative account of bike-uptake to complement the survey. The focus of the interviews largely replicated our proposed survey questions, but we also provided some space for interviewees to mention any other issues they considered relevant. Interviewees were recruited from the survey population sample, which had already been determined at that point. We expressly sought to interview people with contrasting personal backgrounds (e.g. age, gender, car availability) in order to cover the potential range of survey respondents. Since the interviews do not constitute the main focus of the paper, we do not refer to them in the findings, but we occasionally draw upon them in the discussion in order to elaborate on some of the results of the survey.

Since we did not want to specifically restrict the scope of the survey to work/study trips, we adopted a broad definition of commuting as *any regular trip made at least once a week between the same origin and destination*. This potentially includes not only work/study, but also other bike–train trips made on a regular weekly basis (e.g. recurring visits to hospital, recurring social visits). Throughout the paper, all references to "commuting" should be interpreted accordingly. We excluded irregular or variable bike–train trips because it would

[4] More specifically, the geographical scope of our survey was circumscribed to bike-train trips beginning and/or ending in one of the four provinces which are usually considered to be part of the Randstad (North Holland, South Holland, Utrecht and Flevoland).

[5] Further information on the TNS NIPObase panel can be found on the Kantar website (in Dutch only): http://www.nipo.nl/panel/.

have been difficult to fit them within the survey structure; moreover, previous research has shown that regular commuting journeys constitute the large majority of bike–train trips in the Netherlands (Jonkeren et al. 2019).

Based on a number of initial screening questions sent out to the whole TNSNIPObase panel, we identified a narrower group of 3012 eligible respondents who reported travelling regularly by bike–train. From this group, we extracted a stratified random sample of 2331 respondents selected to be representative of the Randstad population in terms of age, gender and province of residence, all of whom were invited to complete the survey. A total of 1439 respondents accepted this invitation, representing a response rate of 62%; this figure is comparable to the reported response rate of previous studies which have also used the TNS NIPObase panel (e.g. 61% in Steur et al. 2017; 67% in Haverman et al. 2014). After a further set of screening questions based on the criteria outlined above (i.e. having started to travel by bike–train on a fixed journey at least once a week, and no longer than five years ago), and manually eliminating a small number of invalid responses, we obtained a total of 493 survey responses.[6] Responses were collected during a period of one month between February and March 2020. Since each respondent has a unique commuting trip associated to them, the total number of respondents coincides with the total number of trips analysed in our results. Our analysis focuses on the characteristics of trips themselves, but also on the motivations which drew the respondents to start making their trip.

Given the primarily descriptive character of our sub-questions, the objective of our analysis was to summarise and interpret our findings, rather than to formally test statistical relationships. After manually checking responses for potential errors, data was processed and analysed using Excel, R and QGIS. In addition, we coded all responses for the open answer questions on the main triggers of bike-uptake into a number of categories or themes. Since the results of the open questions largely replicated those of the closed questions (all of the themes identified were already present in the closed questions), we do not include these in our findings. Nevertheless, in the interpretation and discussion of our findings we occasionally draw upon specific points mentioned in the open questions.

Findings

Sociodemographic and bike–train trip characteristics

In Table 2, we provide a summary of sociodemographic characteristics of survey respondents, compared to the Dutch population as a whole, as well as to all types of train travellers in the four Randstad provinces. Our sample is balanced in terms of gender, but is significantly younger, more educated and has a higher household income than the Dutch average. Such results are largely in line with those of previous studies (Jonkeren et al. 2019; Shelat, Huisman, and van Oort 2018), which also found that bike–train travellers tend to be highly educated, with a large proportion of full-time professionals with high incomes, as well as university and school students. In the case of our survey, 61% of respondents worked for an external employer, while 22% were studying or attending school (the rest were either self-employed or not engaged in paid employment). The household size of respondents was

[6] For some questions, total response counts are somewhat lower as the result of a small number of missing responses to specific questions. In addition, the branching survey logic means that not all questions were asked to all respondents, resulting in further variation to the number of responses for each question.

Table 2 Sociodemographic characterisitcs of survey respondents (n = 493)

	Survey respondents (bike–train travellers)	Dutch population[a]	Train travellers[b]
Mean age	36	42	35
Gender	51% male, 49% female	50% male, 50% female	51% male, 49% female
% university-educated respondents	66%	31% (age 15–75)	57%
Country of origin	94% born in Netherlands	87% born in Netherlands	N/A
Average household size	3.09	2.15	N/A
Modal household income	55% above modal income range 13% in modal income range (€29,000–43,500) 13% below modal income range 19% NA/don't want to say	Modal income: €36,500	45% in top income deciles (8–10) 31% in middle income deciles (4–7) 21% in low income deciles (1–3) 3% N/A

[a]All statistics come from the most recent data available on Statistics Netherlands (CBS)

[b]Data for train travellers come from the Netherlands National Travel Survey (OVIN), and correspond to all types of train users in the four Randstad provinces (North and South Holland, Utrecht and Flevoland), based on the survey from the three most recent years available (2016–2018)

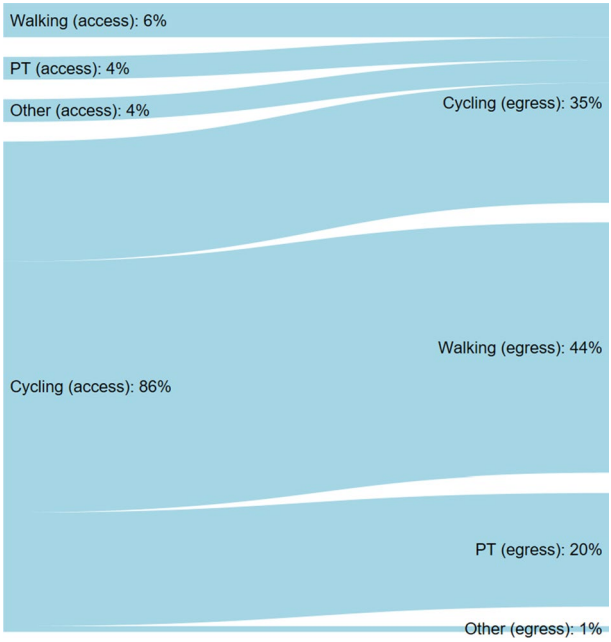

Fig. 2 Bike–train trip chain characteristics (n = 493)

also significantly larger than the Dutch average, reflecting the large proportion of respondents living in a family household. Finally, respondents were overwhelmingly born in the Netherlands. This is likely to be partly attributable to the prevalence of lower cycling levels among people not born in the Netherlands, but might also reflect the income and educational profile of respondents. As previous research has shown, cycling rates in the Netherlands are highest among people with higher income and educational profiles, as well as those with a native Dutch background, all of which tend to be correlated between each other (Nello-Deakin and Harms 2019). If we compare our sample to train travellers in the Randstad in general, we can see that the sociodemographic characteristics of both groups are very similar. While both train travellers and bike–train travellers (i.e. our survey sample) are skewed towards higher income and educational profiles, the proportion of university-educated individuals appears to be a little higher for bike–train travellers.

In Fig. 2, we provide a summary of the bike–train trip chain characteristics of survey respondents. The left side of the figure shows the relative distribution of access modes used to travel to the train station (in percentages), while the right side of the figure shows the distribution of egress modes. The connecting lines between the left and right side provide an indication of the relative size of various access-egress mode combinations: as can be seen, the combination of cycling (access) and walking (egress) is the most common. In agreement with previous research (Jonkeren et al. 2019), bike use is markedly higher on the access than on the egress side (86% vs. 35%). On the access side, the majority of respondents simply use their own regular bicycle (73%), with a much smaller percentage using, e-bikes (7%), folding bikes (5%), bikesharing (< 1%) or OV-fiets (< 1%). For the 35% of respondents also cycling on the egress side, the type of bike used is more varied:

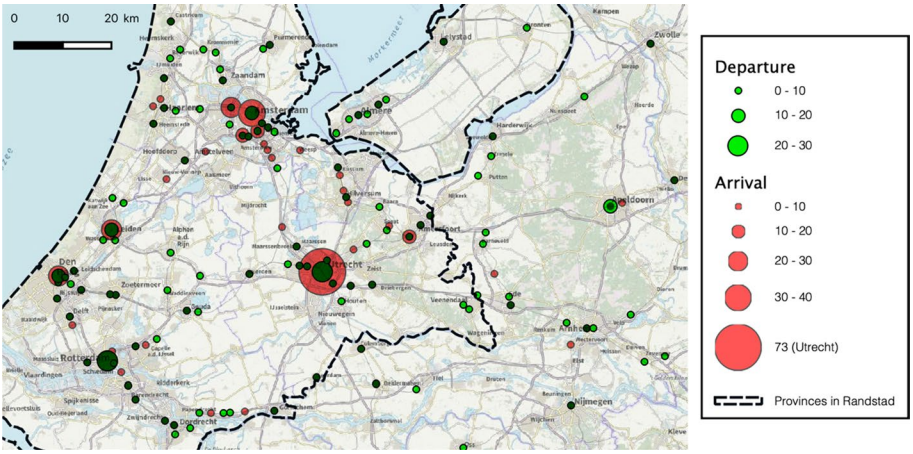

Fig. 3 Departure and arrival train stations of survey respondents (central Randstad area only—some stations fall outside the map boundaries)

while 20% use a "station bike",[7] 6% use OV-fiets, 6% a folding bike, 2% bikesharing, and 1% Swapfiets.[8]

Given our focus on commuting trips—defined as regular bike–train trips made at least once a week—almost all trips were for purposes of work (65%) and study (29%). Nevertheless, a small proportion of trips (6%) were related to other purposes (e.g. sports training, hospital visits, volunteering, family visits). In terms of trip frequency, the largest group of respondents (50%) made their trip 3–4 days a week, followed by 1–2 days a week (35% of respondents) and 5 days a week or more (15%).

Figure 3 provides a geographic visualisation of the departure (i.e. home) and arrival train stations (e.g. work/study) used by survey respondents. This figure provides an indication of the growth of bike–train trips to, from and within the Randstad in recent years. As can be seen, the main arrival stations correspond to poles of employment and study in the Randstad's main cities (i.e. Amsterdam, Utrecht, The Hague, Rotterdam and Leiden). Departure stations are more diverse, with a much larger proportion of trips originating in smaller towns with a more suburban or residential character (e.g. stations north of Amsterdam). While the volume of departure and arrival trips is relatively balanced in some cities (e.g. Rotterdam)—other cities act mainly as either origins (e.g. Almere) or destinations (e.g. Amsterdam, Utrecht). To a large extent, these imbalances reflect broader daily mobility and home-work patterns within the Randstad area, as well as regional economic trends over the past couple of decades (van Eck and Snellen 2006). Nevertheless, the relative importance of Utrecht seems remarkable given its comparatively small population size; at least in part, its prominence is likely to be attributable to Utrecht's position as a key hub within the Dutch railway network, which makes it the busiest station in the Netherlands.

[7] A "station bike" is a privately-owned bike which typically spends most of the time parked in or in the vicinity of a train station, which is owned for the specific purpose of enabling last mile commuting trips from arrival train stations.

[8] *Swapfiets* is a long-term bike subscription service, in which users pay a fixed monthly fee to rent a bike, and rely on the company for bike maintenance and service. This service has expanded rapidly in recent years, and is particularly popular among university students.

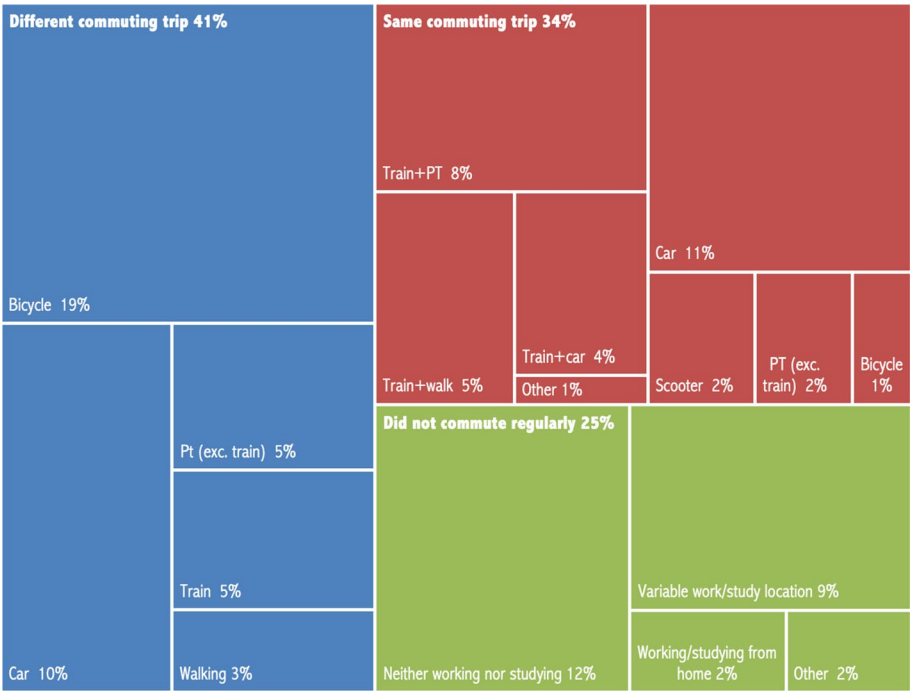

Fig. 4 Previous commuting practices replaced by bike–train trips (n = 487)

Travel behaviours replaced by bike–train

In answer to our first sub-question, our survey distinguished between three categories: (1) people who previously made a different commuting trip (with a different origin and/or destination); (2) people who previously commuted between the same origin and destination but used a different mode of transport[9]; and (3) people who previously did not commute regularly.

Figure 4 provides a visual summary of the relative proportion of respondents in these three categories. Note that in the case of different commuting trips (in blue in Fig. 4), we only distinguish between the *main* transport mode previously used by respondents, regardless of whether it was a single or multi-modal trip. For multi-modal trips involving the train in the "same commuting trip" category (in red in Fig. 4), we also do not differentiate whether the mode which was replaced by cycling was on the access or on the egress side (or on both sides).

As the relative spread of respondents between different categories suggests, the travel behaviours being replaced by bike–train trips are quite varied, with no single category clearly dominating the rest. 41% of respondents used to make a different trip; 34% made

[9] By "different mode of transport", we refer to all kinds of trips which did not previously involve the combined use of the bicycle and train. This includes previous train trips with different access and/or egress modes (instead of cycling), but also trips which previously involved a different main mode instead of the train.

the same trip but using a different mode (or combination of modes); and 25% did not commute regularly. The largest individual group corresponds to respondents who used to make a *different trip by bicycle* (19%), followed by respondents who did not commute because they were *neither working nor studying* (12%), and respondents who used to make the *same trip by car* (11%).

It is also interesting to consider the overall modal shift from other transport modes to bike–train regardless of whether respondents used to make the same or a different trip. If we combine the results for the "same commuting trip" and "different commuting trip" categories, we can see that 22% of respondents already commuted by train before, either alone or in combination with other modes. Leaving train trips aside (and their accompanying access/egress modes), the main transport mode being replaced by bike–train trips is the car, with 21% of respondents undergoing a modal shift from car to bike–train (11% replacing the same trip, and 10% replacing a different trip). This is followed by 20% of respondents who shifted from cycling-only to bike–train trips, and 7% of respondents shifting from public transport (excluding train).

Triggers of bike–train uptake

Our second sub-question aimed to identify potential triggers of bike–train uptake; our survey questions on this topic were somewhat different for each of the categories described in the previous subsection. For respondents who had shifted to travelling by bike–train on a trip they already made using a different mode, our aim was to identify the main reasons for their *modal shift*. For respondents who had started making a *new trip* by bike–train, our aim was to identify the main reasons why their trip had changed, or why they had started making this trip in the first place. Accordingly, we present our findings separated into two categories: *modal shift trips* and *new trips*.

Modal shift trips

As a means of operationalising the list of triggers provided in the conceptual framework (see Table 1), and drawing upon our findings from the exploratory qualitative interviews, our survey presented respondents with five overarching categories of potential triggers of bike–train uptake for modal shift trips: improvements to train services or cycling facilities; dissatisfaction with existing travel mode; changes in personal life; changes in professional life; and changes in available transport options. The survey first asked respondents to choose which categories best reflected their reasons for switching to bike–train, and then presented them with a variety of more concrete options for their selected categories. In Table 3, we provide a summary of our results for this question.[10] As can be seen, the most frequent overarching reason for switching to bike–train is dissatisfaction with the existing travel mode, followed by changes in available transport options. If we look at concrete triggers, "too much traffic congestion" occupies the first place, followed by "improved train services".

In addition, a separate question asked respondents whether their switch to bike–train had also been influenced by a disruptive event, to which 41 out of 168 (24%) of respondents

[10] Note that the possibility of selecting multiple options means that total response counts do not match the number of respondents.

Table 3 Triggers of bike–train uptake for modal shift trips (n = 168)

Category	Trigger	Counts
Unsatisfied with existing travel mode (61)	Too much traffic congestion	25
	Too slow	19
	Too expensive	18
	Too unpleasant	14
	Too unreliable	7
	Parking became too difficult/expensive	2
Change in available transport options (44)	Stopped having car available	17
	Acquired a bicycle	14
	Change in train/PT services (e.g. timetables, routes)	12
	Acquired train season ticket	8
	Bikesharing/bike rental service became available	3
Changes in personal life (35)	Change in trip chaining	13
	Reduction in income level	12
	Change in household composition	10
Improvements to train services or cycling facilities (34)	Improved train services	20
	Improved bike parking facilities at station	13
	Increased availability of bikesharing/OV-fiets at station	9
	Improved cycling infrastructure in journey to/from station	7
Changes in professional/educational life (20)	Change in working hours	16
	Change in workplace travel policy	7
None of the above (10)		

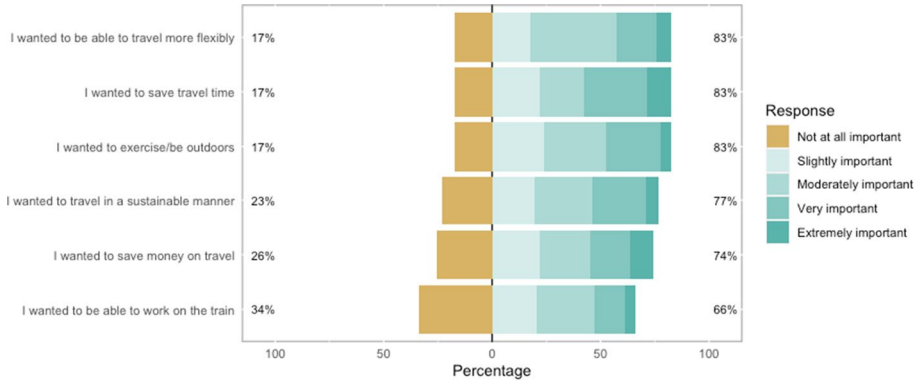

Fig. 5 Motivations for switching to bike–train (relative % of answers in each category, n = 168). The results for "work on the train" are based on a lower number of responses (n = 83), since this option was only displayed as a potential motivation to respondents who did not already travel by train

replied affirmatively. Stated disruptions included road closures (18), public transport strikes (16) and traffic accidents (7).

Apart from seeking to identify concrete triggers of bike–train uptake, our survey also included a Likert scale question seeking to assess the importance of various motivations in contributing to this modal switch. While some of these motivations can be seen as closely related to some of the triggers presented in Table 3, they do not reflect distinct triggers or key events, but rather underlying rationales for switching to travelling by bike–train. As

Table 4 Triggers of bike–train uptake for new trips (n = 322)

Previous commuting behaviour	Trigger	Counts
Made a different commuting trip (n=201)	Change in work/study location	163
	Change in home location	45
	Other	1
Did not commute regularly (n=121)	Started studying	51
	Change in work/study location	29
	Started working	28
	Other	21

Fig. 5 illustrates, utilitarian considerations such as flexibility and travel time appear to be the most common motivations for switching to bike–train, but are closely followed by less instrumental considerations such as the wish to exercise and travel more sustainably.

Finally, and in order to better understand the temporality of the process of bike–train uptake, we asked respondents to whether they thought their decision was primarily the result of (1) a concrete event or a sudden change; or (2) a gradual reflection or long-term development. The majority of respondents (57%) chose the second option, suggesting that in most cases, the decision to switch to bike–train cannot be neatly attributed to a single discrete event or trigger, but is rather the outcome of complex evolving interactions between various circumstances (e.g. long-term processes, changes in personal life, motivations).

New trips

In comparison to the previous subsection, the main triggers for bike–train uptake among respondents starting to make a *new* trip by bike–train (as opposed to replacing an existing trip) were relatively straightforward, and almost entirely attributable to changes in home or work/study location. In Table 4, we present the main triggers of bike–train uptake for new trips, divided into two categories based on respondents' previous commuting behaviour.

For respondents who used to make a *different commuting trip*, changes in work/study location constitute by far the most common trigger of bike–train uptake, followed by changes in home location.[11] In order to better understand the relation between relocation and bike–train uptake, respondents were asked to compare the relative level of public transport provision between their previous and current work/home neighbourhoods. In the case of changes in work location, our results suggest that bike–train uptake is associated with an improvement in public transport accessibility: 55% of those moving jobs thought public transport provision was better in their current work location, compared to only 15% who thought it was better in their previous work location. For changes in home location, however, no clear comparable trend was observed. In addition, 66 respondents who had moved to a new place of work/study reported that this had been accompanied by a change in workplace travel policy. In most cases, these changes tended to encourage public transport or cycling over car use: among others, respondents reported being reimbursed for public transport but not driving (38 respondents), being dissuaded from travelling by car (9) or no longer having access to a company car (7).

For respondents who previously *did not commute regularly*, the most common trigger of bike-uptake was starting to study, followed by changes in work/study location and

[11] In a small number of cases, respondents changed both jobs and homes at the same time.

starting to work. Full-time students in the Netherlands usually receive free public transport throughout the whole country, a fact which helps explain why beginning to study constitutes an important driver of bike–train uptake. Indeed, multiple respondents noted that receiving free train travel had been an important reason for choosing to travel by bike–train above other transport options.

Among all respondents who had started making a new trip by bike–train (regardless of whether they previously made a different trip or did not use to commute regularly) 58% considered that they did so because they had no other good options available, while the remaining 42% stated that they had other good travel options, but actively preferred to commute by bike–train. Despite the somewhat subjective nature of these choices, this suggests that a significant number of respondents feel compelled to travel by bike–train because they think they have no other alternative, thereby arguably constituting "captive" bike–train users.

Social environment factors

Both for modal switch and new trips, the survey included a set of questions designed to capture the potential influence of respondents' social environment on their uptake of bike–train. To this end, respondents were asked whether they knew anyone else in their acquaintance circles who also commuted regularly by bike–train. 76% of respondents reported that they did, including work/study colleagues (49%), friends and acquaintances (32%) and family/household members (25%). When asked about whether they thought knowing someone else who commuted by bike–train had affected their decision to start commuting by bike–train, however, only 23% of respondents thought this had influenced their decision. However, this percentage is significantly higher for respondents switching to bike train on an existing trip (34%) than for respondents beginning to make a new bike–train trip (18%), suggesting that knowing other people who commute by bike–train can play a significant role in encouraging *modal switch* to bike–train.

In addition, respondents travelling by bike–train for work/study were asked to rank the most common travel modes among their workplace (or study) colleagues. Train travel (alone or in combination with other modes) was ranked as the most common mode of commuting among colleagues in 49% of cases, followed by driving (32%) and cycling (13%). This suggests that many respondents work/study in an environment where train travel is common (and much higher than the Dutch average). However, this preponderance of train travel at respondents' workplaces may be attributable to physical location and accessibility conditions just as much as social environment factors. Here again, we also found an interesting difference between respondents switching to bike–train on an existing trip and respondents making a new trip by bike train. In the first group, car travel was considered the most frequent commuting mode among colleagues, while in the second train travel was considered more common. This suggests that people switching to bike–train on their existing trip are more likely to have a personal reason for doing so despite working in environment where car travel is more common, whereas people making a new bike–train trip simply take the train because it is the most logical option.

Relationship with existing travel behaviour

Our third sub-question explored the relationship between bike–train uptake and previous travelbehaviour. Figure 6 provides a summary of respondents' previous travel habits

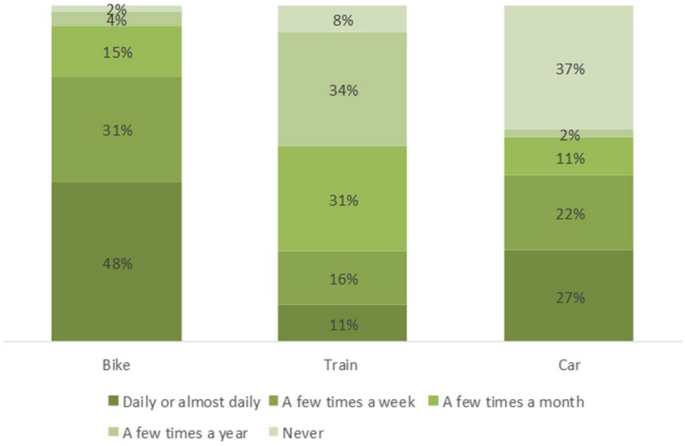

Fig. 6 Frequency of use of different travel modes before beginning to commute by bike–train (n = 491)

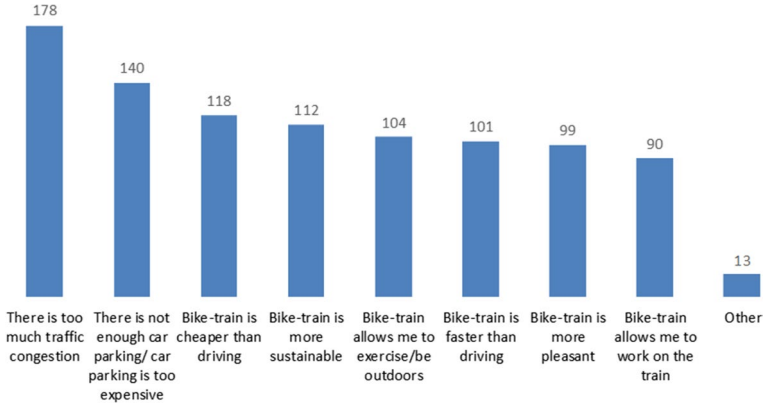

Fig. 7 Main reasons for preferring to commute by bike–train than by car (only respondents with a car available, n = 328)

before they began to commute by bike–train. Confirming our initial expectations, the survey results showed that the majority of respondents already cycled regularly at a local level before beginning to travel by bike–train: almost 50% reported cycling daily, with a further 31% cycling a few times a week. Close to all respondents (99%) already owned a bike[12] before beginning to commute by bike–train, a figure which is extremely high even by Dutch standards: average bike ownership in the Netherlands has been estimated at 84%.[13] In most cases (78%), respondents had started to commute by bike–train using their pre-existing bike; only a small minority of respondents had bought a bike for the specific purpose of commuting by bike–train.

[12] In 32% of cases respondents owned not only one, but actually but two or more bikes.

[13] Source: https://www.fietsplatform.nl/uploads/Verdieping-2013-Fietsfeiten-Effecten-fietsbezit.pdf.

Previous train usage among respondents was much less frequent: the majority of respondents did not use the train more than a few times a month. In contrast to cycling, this suggests that regular train travel does not constitute a precondition for bike–train. Previous car usage among respondents, finally, appears to follow more of a bimodal distribution, with most respondents using the car either very frequently or (almost) never; this suggests the existence of fairly clear divide among respondents between car-based and carless lifestyles.

Furthermore, 66% of respondents reported having a car available[14] which they could in principle use for their commuting trip instead of bike–train. A small additional number of respondents (3%) did not have a car available despite owning one, because this car was primarily used by someone else in their household. As these results indicate, the majority of respondents actually *do* have a car available but prefer to commute by bike–train. In Fig. 7, we provide a summary of the main reasons reported by these respondents for preferring to travel by bike–train rather than by car. To a large extent, many of these reasons echo the triggers and motivations of bike–train uptake presented before.

In contrast, 34% of respondents did not have a car available. Out of the 20% who had no car available but nevertheless had a driving license, 14% reported that they would still prefer to commute by bike–train even if they had a car available, while the remaining 6% stated that they would be likely to switch to commuting by car. Among this last group of respondents, main reasons for preferring the car included faster travel times, more flexibility and more private space. Interestingly, the majority of the respondents who did not own a car despite having a driving license (56 out of 97) considered that they would be more likely to buy a car if they were not able to commute by bike–train, suggesting that the ability to travel by bike–train plays an important role in facilitating a car-free lifestyle.

Discussion and conclusion

To conclude the article, we briefly discuss our findings for each of our three sub-questions. This is followed by a more overarching conclusion, in which we bring these different threads together in order to discuss overall trajectories of bike–train uptake. Last but not least, we reflect on the limitations of our research and provide directions for further research.

Travel behaviours replaced by bike–train

In part, our findings suggest that bike–train uptake supports a shift towards sustainable mobility. Our survey presented clear evidence of a modal shift from car to bike–train, with 21% of respondents stating that they previously used to commute by car (either on the same or on a different journey). Moreover, most respondents who did not own a car despite having a driving license (58% within this category, or 11% out of the total survey sample) considered that they would be more likely to buy a car if they were unable to commute by bike–train. This suggests that the bike–train system plays an important role not only in attracting existing car drivers, but also in reducing the need for a car among carless

[14] In most cases this refers to privately owned cars (50% of respondents), but also includes company/lease cars (8%) and carsharing (7%).

individuals (at least within the context of a large regional conurbation like the Randstad). The lack of previous research exploring the modal shift dynamics associated to bike–train uptake makes it difficult to compare our results with those of other studies; nevertheless, our results fall broadly in line those of a previous survey of OV-fiets users, which found that the bike–train combination had replaced car trips for 15% of respondents (Martens 2007).

At the same time, many respondents (19%) started commuting by bike–train in order to replace a cycling-only journey, typically following a change in work or residential location. In these cases, modal shift towards bike–train travel rather seems part of a trend towards the regionalization of travel patterns and increasing home-work distances—a trend which arguably represents a move away from the sustainable ideal of proximity-based mobility. In addition, our findings suggest that a significant proportion (25%) of bike–train uptake trips is not related to modal shift from other modes, but rather from respondents beginning to commute regularly in the first place. Whether we see these trips as positive from the perspective of sustainability depends on what we compare them to: while they might be considered as preferable to car travel, one might also argue that a more sustainable solution would be to reduce the need to start making long commuting trips in the first place.

Triggers of bike–train uptake

In almost two thirds of cases, our findings show that bike–train uptake is prompted by a change in home, work or study location. This confirms the crucial role of residential relocation and changes in employment as the two most common triggers of changes in travel behaviour (Rau and Manton 2016; Schoenduwe et al. 2015). In particular, moving to a new job or study location in a central urban area which is highly accessible by train but less so by private car appears to be a critical trigger of bike–train uptake.

In the majority of cases, bike–train uptake does not appear to be attributable to a single trigger, but rather to the interplay between specific events, long-term processes and underlying motivations. As noted by Verplanken et al. (2008), changes in context often activate underlying values and motivations (e.g. sustainability, wish to exercise) which contribute to a reconsideration of travel choices. In this respect, our findings echo those of Kent et al. (2017), who found that changes in transport practices are often not the result of a "single shock", but the result of a "bundling and re-ordering of practices". This "bundling" is apparent in the survey responses, in which most respondents noted that their choice to start commuting by bike–train was influenced by multiple factors, but was even more evident during the preliminary interviews. As one interviewee explained, she had started commuting by bike–train (instead of driving) after she had started working at a new school which was closer to home, but in a more urban setting with no free car parking available; precisely at the same time, her existing car had become so old that it would have needed replacing. Initially, she started commuting using an e-bike she had lent from her mother, but she eventually had to give it back, so she turned to the bike–train combination instead. As this story illustrates, it is difficult to untangle the role of different factors: while the lack of car parking at the interviewee's new workplace might be seen as the "critical" factor prompting a shift to bike–train, it is difficult to say whether she would have also turned to the bike–train combination without the existence of contributing factors (i.e. car becoming too old, interim period commuting by e-bike). Admittedly, in some cases there *is* a clearly identifiable single trigger of bike–train uptake: another interviewee noted that he had started cycling to work from his arrival train station simply because his employer had

decided to provide employees with a free subscription to the OV-fiets bike rental system. More commonly, however, the existence of multiple triggers makes it hard to assign primacy to a single trigger.

In most cases, our findings suggest that people's decision to start commuting by bike–train (either on an existing or a new trip) is driven primarily by practical considerations such as travel time, cost, and convenience. "Push" factors appear to be generally more important than "pull" factors in encouraging bike–train uptake, even though it can sometimes be difficult to make a clear distinction between these two categories. In particular, perceptions of traffic congestion—and to a minor degree, the cost and difficulty of car parking—appear to play a key role in persuading car drivers to start travelling by bike–train instead. Somewhat paradoxically, one might argue that the excessive "success" (and ensuing saturation) of the car-based mobility system constitutes one of the main drivers of growth in bike–train usage. However, our findings also suggest that in many cases, the bike–train combination scores well in terms of many "utilitarian" attributes which are often attributed to the car, such as speed, efficiency and flexibility.

While more affective motivations (e.g. wanting to exercise or travel more sustainably) were also noted as important factors by most respondents, we suspect that in some cases they might have constituted somewhat of a post hoc justification: at least, this certainly appeared to be the case in some of the interviews. As recent research has noted (e.g. Janke and Handy 2019; Kroesen et al. 2017), an increasing amount of evidence suggests that the relationship between travel behaviour and attitudes is bidirectional: attitudes towards different travel modes do not only shape travel choices, but are themselves affected by changes in travel mode as a result of life events (e.g. home/work relocation).

Nevertheless, the interviews also suggested that the intrinsic qualities and enjoyment of cycling might potentially play a more important role in the choice to start travelling by bike–train than captured in our survey: the fact that the intrinsic qualities of cycling are often hard to put into words (and measure in a survey) should not lead us to underestimate their importance (Krizek 2018; Liu, Krishnamurthy and van Wesemael 2018; te Brömmelstroet et al. 2019). Indeed, cycling is one of the transport modes which scores highest in terms of its positive affective qualities, with cyclists being among the happiest commuters (Wild and Woodward 2019). While affective appraisals of train travel tend to be less positive, various survey respondents noted that they also enjoyed certain aspects of the train journey. In this respect, we can also question whether some of the rational and utilitarian motivations for bike–train use captured in the survey may not constitute post hoc justifications—at least in some cases—for affective or ideological motivations. As previous research has shown—especially in the case of car driving—people often prefer a specific mode because of affective or ideological motives, but justify their choice in "rational" terms related to time and cost (e.g. Anable and Gatersleben 2005; Steg 2005). Up to a certain point, this is likely to be equally true for the combination of cycling and train travel.

Workplace travel policies which encourage train or bike travel and discourage car use – typically but not only in the form of economic incentives such as train travel reimbursement – also appear to have an important effect in prompting people to start travelling by bike–train. A particular instance of this are students, who in the Netherlands benefit from free public transport throughout the country. This points out to the critical importance of "soft infrastructure" in the form of legislation, regulation and fiscal incentives in encouraging a bike–train uptake. Indeed, the Netherlands has a comparatively well-developed set of fiscal policies related to commuting which tend to favour sustainable transport modes (Harding 2014). As we see it, this constitutes a takeaway for other countries seeking to encourage bike–train use. While our findings show that improvements to the bike–train

system itself (e.g. better train services, bicycle parking at stations) constitute significant reasons for bike–train uptake for some respondents, their relative weight appears to be comparatively small. From a policy perspective, this suggests that measures discouraging car use, as well as "soft" measures such as workplace incentives, are likely to be more effective in encouraging bike–train use. This does not mean, however, that investments in the bike–train system are superfluous: while expensive underground bike parking at train stations may not be the main reason why people decide to start travelling by bike–train, for example, they may very well be a *necessary* requirement to enable the continued growth of bike–train travel.

Finally, there appears to be some evidence that knowing other people who also commute by bike–train may contribute to some people's decision to start travelling by bike–train, particularly for people switching to bike–train on an existing trip. Nevertheless, the role of the social environment proved difficult to assess; in part, this may be due to the difficulty of meaningfully capturing its influence through a closed survey question, but is also attributable to the fact that in the Netherlands, most people find themselves in a favourable social environment for cycling by definition (Nello-Deakin and Nikolaeva 2020).

Relationship with existing travel behaviour

In terms of the relationship between bike–train uptake and previous travel behaviour, our results show that a large majority of respondents already cycled regularly at a local level. As we see it, this suggests that bike use at a local level largely constitutes a *precondition*—albeit not a strict one—for bike–train uptake. Admittedly, our results need to be understood within the context of the Netherlands, where the majority of the population *does* cycle regularly, with an average of 0.79 trip cycling trips per day.[15] Nevertheless, this presents an important implication for other countries: namely, that it might be difficult to encourage bike–train use without first building up a critical mass of cyclists at a local level. Following this reasoning, attempting to promote bike–train use level in the absence of an established local cycling culture at a local seems akin to putting the cart before the horse.

Regular train use, meanwhile, appears to be much less of a precondition for bike–train use: a substantial proportioned of respondents rarely or almost never travelled by train before beginning to commute by bike–train.

Car use and availability, finally, do not appear to be as strongly (inversely) related to bike–train uptake as one might initially suppose. Although approximately a third of respondents did not have access to a car, our results show that the majority of respondents *do* have a car available. In this respect, our findings contrast with those of Krygsman et al. (2004), who reported that 80% of multimodal train users do not own a car, but are largely in line with those of Shelat et al. (2018), who found that a substantial number of bike–train users have access to a car. This belies the assumption that most bike–train users choose to travel this way simply because they do not have a car available: as our results show, many people actively *prefer* to commute by bike–train despite owning a car, both for utilitarian reasons and affective ones. Similarly, only a minority of respondents with a driving license but no car available stated that they would prefer to travel by car than by bike–train. These results lend strong empirical support to the idea that bike–train travel *can* provide a more attractive alternative to the private vehicle for interurban travel (Martens 2004; Kager et al.

[15] Statistics Netherlands (CBS), 2020.

2016), at least in a context with high-quality rail infrastructure services and cycling facilities like the Randstad.

Summary: overall trajectories of bike–train uptake

Our study shows that trajectories of bike–train uptake are relatively varied, with no single trajectory dominating strongly over the rest. In general terms, our findings suggest that we can distinguish between three broad respondent profiles, which we list below:

1. People who are dissatisfied with their existing commuting mode, and decide to switch to commuting by bike–train instead. By and large, people in this category fall into two groups: car drivers, and people who already took the train, but who instead of cycling used to reach the station by public transport or by foot.
2. People who start travelling by bike–train following a change in their work or home location which leads them to re-evaluate their commuting options. Within this category, the largest group corresponds to people who previously used to make a cycling-only trip, but whose new trip is too long to cycle. The second largest group corresponds to previous car drivers who find that bike–train provides a better alternative for their new commuting trip.
3. People who did not use to make any regular commuting trips, but who start to commute by bike–train after beginning a new job or study. Typically, respondents choose to travel by bike–train above other transport option simply because they see it as the most effective choice available to them.

In part, our findings agree with the notion that the growth in bike–train travel in the Randstad supports a "scaling up" of cycling cities like Amsterdam and Utrecht beyond their natural geographical limits. As our results show, the overwhelming majority of new bike–train commuters are already existing cyclists, and a substantial proportion of them start travelling by bike–train in order to replace a cycling-only trip a local scale. At the same time, the growth of bike–train travel can also be seen not as a scaling up of cycling practices, but rather as an optimisation of existing train travel practices, building on established patterns of transit-oriented mobility and regional development (Lee, Choi and Lim 2016). Indeed, many people do not start travelling by bike–train to replace a completely different transport mode, but rather to "optimise" their existing train trip. These two narratives are complementary, rather than mutually exclusive: in this respect, our findings support Kager et al.'s (2016) contention that the bike–train combination should be seen as a hybrid mode which *combines* characteristics of both cycling and train travel, rather than a variant of either transport mode.

As evidenced by the substantial number of car drivers switching to bike–train, there appears to be strong evidence that the bike–train system can provide a competitive alternative to car for many trips, especially for urban locations which are better accessible by rail than by car. Our results suggest that the bike–train combination is seen as comparatively attractive partly because of instrumental advantages such as travel time, speed and cost, but also because of more subjective ones such comfort, the ability to be outdoors and exercise, and personal motivations such as wanting to travel more sustainably. Critically, our findings suggest that the comparative advantage of bike–train in relation to car travel is not a structural one but a contingent one, which is actively maintained by "soft" incentives such

as work travel policies and subsidised train travel and, as well as by "push" factors which make the car less attractive (e.g. lack of car parking, traffic congestion).

To a large extent, our research confirms the importance of many of factors which encourage bike–train use reviewed in van Mil et al. (2020). However, the present study also highlights the significance of various "push" factors in promoting a modal shift to bike–train which have received less attention up to the present: in particular, *traffic congestion* appears to play a notable role in prompting people to start travelling by bike–train. In addition, our findings point out to the importance of work travel policies in encouraging bike–train use, a factor not considered in the review by van Mil et al. (2020). The survey results also suggest that improvements in cycling infrastructure play a relatively minor role in attracting new bike–train users within the Dutch context, in contrast with less developed cycling contexts where the availability of cycling facilities is likely to play a more important role (e.g. Janke and Handy, 2019).

In relation to the overall key events literature, our study confirms the importance of work and residential relocation as arguably the two most common triggers of changes in travel behaviour. As argued by Müggenburg et al. (2015) and Scheiner et al. (2016), our findings also support the view that employment-related events have a more significant effect on change in travel behaviour patterns than family-related events, largely because of the greater frequency of workplace as opposed to residential relocation. In addition, our results also support Scheiner et al.'s (2016) conclusion that a reduction or worsening in car parking can be a key factor in promoting a modal shift away from private car. However, our findings also suggest that such events rarely come alone: more often than not, we can speak of a bundling of interrelated events in which it is not always possible to attribute primacy to a specific trigger. Moreover, our findings suggest that in many cases respondents do no change travel behaviour because of a distinct trigger, but rather as the result of a gradual interplay between specific events, long-term processes and underlying motivations.

Limitations and future research directions

As a result of our focus on the Netherlands, where almost everyone has a pre-existing "cycling habitus" (Kuipers 2013; Nello-Deakin and Nikolaeva 2020), our study's ability to gauge the importance of previous familiarity with cycling in contributing to bike–train uptake is inevitably limited. While our findings show that people who take up bike–train tend to be regular cyclists who operate in a social environment where bike–train use is common, the relative lack of "non-cyclists" in the Netherlands makes it difficult to falsify this claim. It would therefore be interesting to replicate the approach of the present study in a context with low cycling rates, in order to see whether previous familiarity with cycling is equally observed to be a precondition of bike–train uptake. More generally, it would be valuable to study bike–train uptake in geographic contexts where physical conditions for bike–train use (e.g. transport infrastructure, land use) are often lacking, in order to explore the extent to which the observed triggers of uptake are similar to those identified in the present study.

Secondly, our study focused only on regular bike–train trips between a fixed origin and destination. As previous research has suggested (Kager et al. 2016), one of the potential key advantages of the bike–train system is its flexibility, since it allows people choose between different stations and vary their cycling trip depending on their fluctuating daily mobility needs. Accordingly, it would be worthwhile for future research to investigate not

only regular but also irregular bike-trips, as well as to explore the main factors shaping variability in bike–train travel.

A third direction for further research is studying the effect of active interventions on bike–train uptake. Our study sought to map an overall picture of the triggers of bike–train uptake, but did not specifically focus on the studying the effect of active interventions in encouraging people to travel by bike–train. Living labs, pilot experiments and the introduction of new innovations such as bikesharing (e.g. Ma et al. 2020) could offer a valuable opportunity to assess the effect of such interventions on bike–train uptake.

Finally, further research—both qualitative and quantitative—would be useful in deepening our understanding of the temporal and causal processes of bike–train uptake. While our research incorporated a more qualitative element in the form of in-depth preliminary interviews and a couple of open survey questions, the primary aim of our survey was to map common trajectories and triggers of bike–train uptake at an aggregate level, rather than to provide a detailed exploration of the dynamics of bike–train uptake. In addition, the need to keep the survey length relatively short meant that we were unable to break down some of the concepts used in the survey (e.g. "improved train services", "change in household composition") into more specific categories in order to inform a more detailed interpretation of the results. Further in-depth qualitative research in, we suggest, would be useful in helping unpack the complex temporal and causal interactions between different factors in encouraging bike–train uptake at an individual level, as well as in obtaining a more detailed understanding of these factors. In addition, more targeted quantitative research geared towards statistically testing the effect of specific factors on bike–train uptake would allow to test some of the causal relationships hinted at in our study in a more rigorous and in-depth manner. To give a specific example, it would be interesting to carry out a more detailed study seeking to statistically assess which changes in local urban environment characteristics are most closely associated with bike–train uptake in cases of residential or work relocation.

Appendix: Survey outline

1. Characteristics of current bike–train trip
    a. Start date, frequency and purpose
    b. Origin and destination of trip (postcode and train station)
    c. Access and egress mode
2. Previous trip characteristics
    a. Commuting behaviour before bike–train uptake
3. Triggers of bike–train uptake (*new trips* only)
    a. Reasons for change in origin/destination of commuting trip*
    b. Reasons for starting to commute regularly*
    c. Reasons for choosing to commute by bike–train over other transport modes
    d. Changes associated to home/work relocation*
    e. Modes of transport used to commute by work/study colleagues
    f. Prevalence of bike–train commuting among acquaintances

4. Triggers of bike–train uptake (*modal switch* trips only)
    a. Reasons for switching to commute by bike–train
    b. Effect of disruptive events on bike–train uptake
    c. Motivations contributing to bike–train uptake
    d. Modes of transport used to commute by work/study colleagues
    e. Prevalence of bike–train commuting among acquaintances

5. Previous bike and train use
    a. Bicycle use before bike–train uptake
    b. Train use before bike–train uptake

6. Car use and availability (only respondents with driving license)
    a. Car use before bike–train uptake
    b. Current car availability
    c. Effect of car availability on choice to commute by bike–train
    d. Reasons for preferring bike–train/car

7. Bicycle ownership
    a. Bicycle ownership before bike–train uptake
    b. Bicycle used for current for current bike–train trip

*Indicates that this section only applied to a specific group of respondents.

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Compliance with ethical standards

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