<table>
<thead>
<tr>
<th><strong>Title</strong></th>
<th>Pedestrian and cyclists sharing facilities in Singapore</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Author(s)</strong></td>
<td>Rojas Lopez, Maria Cecilia; Wong, Yiik Diew</td>
</tr>
<tr>
<td><strong>Date</strong></td>
<td>2017</td>
</tr>
<tr>
<td><strong>URL</strong></td>
<td><a href="http://hdl.handle.net/10220/43600">http://hdl.handle.net/10220/43600</a></td>
</tr>
<tr>
<td><strong>Rights</strong></td>
<td>© 2017 The author(s). This paper was published in Proceeding of International Velo-City 2017 Conference: The Freedom of Cycling. The presented slides is available at: [<a href="https://ecf.com/sites/ecf.com/files/MariaCeciliaRojasLopez_PedestriansAndCyclistsSharingFacilitiesInSingapore_0.pdf">https://ecf.com/sites/ecf.com/files/MariaCeciliaRojasLopez_PedestriansAndCyclistsSharingFacilitiesInSingapore_0.pdf</a>]. One print or electronic copy may be made for personal use only. Systematic or multiple reproduction, distribution to multiple locations via electronic or other means, duplication of any material in this paper for a fee or for commercial purposes, or modification of the content of the paper is prohibited and is subject to penalties under law.</td>
</tr>
</tbody>
</table>
Rojas Lopez, Maria Cecilia  
PhD Candidate  
mariacec001@e.ntu.edu.sg  
School of Civil and Environmental Engineering  
Nanyang Technological University, Singapore

Wong, Yiik Diew  
Associate Professor  
CYDWONG@ntu.edu.sg  
Centre for Infrastructure and Systems  
School of Civil and Environmental Engineering  
Nanyang Technological University, Singapore


Abstract

Singapore is a small, densely populated, and highly urbanised island city-state. More than 12% of the available land in the nation is dedicated to transport facilities. An elevated percentage compared with the 14% land use dedicated to housing. Pedestrians and cyclists commonly share transport facilities necessitated by the limited land space. From a relatively low base of 1-2% cycling as a main transport mode and moderated walking rates, active mobility (walking and cycling) is now increasing in popularity. Thus, “shared facilities” need to be comprehensively planned. Comfort, accessibility, and safety of users need to be carefully considered. This study summarises planning and spatial characteristics of shared facilities in Singapore. Perception surveys were employed to explore the impact of different characteristics of shared facilities on: (1) users’ travel behaviour; (2) attitudes towards walking and cycling; and (3) active mobility demand. Users of different demographics were surveyed. The relationship between pedestrians and cyclists travelling requirements/needs and actual shared facilities operating conditions is established. Providing impetus to establish planning and management standards for such facilities. Transport schemes and policies to increase active mobility demand, especially cycling, while maximising aforementioned factors (comfort, accessibility, and safety), are discussed.

Keywords: Shared spaces, cycle, walk, cycling infrastructure, demand increase

Theme: People  
Format: Pecha-Kucha

1. Introduction

Economies and people are constantly adapting to meet the demands of today’s urbanised world. This can clearly be seen in the provision of transport infrastructure and people’s preferences towards certain modes of transport. In the search for sustainability and efficiency, many travellers are opting for active modes of transport, mainly walking and cycling, and some opt for other personal mobility devices (PMDs). Active modes of transport not only provide physical and mental benefits to user’s but are also space efficient (Pucher & Buehler, 2010). Active mobility can thus help to reduce traffic congestions caused by urbanisation.

Important amount of research is being focused on active modes of transport. Many are studying the interactions among active transport users while others concentrate on infrastructure provision. Provisions for motorised and active transport modes are most commonly planned according to landscape, traffic density and weather conditions. Ideally, each mode of transport should have its own commuting space. This
to minimise the number of conflicts between users and the risk of transport-related accidents (Gössling et al., 2016). However, due to limited land space, some resort to share spaces. In many cases, cyclists have to share the same right-of-way either with vehicles on the roads or with pedestrians on the pathways. Motorist-cyclist interaction and/or cyclist-pedestrian interaction affect road/pathway design, with due considerations of comfort, accessibility and safety.

Singapore is a relatively small and very dense island-nation (716 km² land area and 5.47 million habitants (SINGSTATS, 2014; Tham, 2014)). Notwithstanding its high level of urbanisation, the country has maintained over 50% of greenery, including green roofs and vertical gardens (Gardner et al., 2016). Much effort has been placed in the planning and provision for transport. As other countries in the world, Singapore is facing the challenge to provide suitable commuting space for active modes of transport. As walking and particularly cycling continue to increase in popularity in the country, so does commensurate infrastructure requirements for pathways, crossings, and parking spaces. In the local context, initial provision for cycling facilities had focused on recreational cycling (Koh & Wong, 2015). Apart from designated cycling spaces (mostly parks), cyclists are legally required to be on the roads. However, utilitarian cycling is rapidly gaining popularity, with most utilitarian cyclists – illegally – riding on the pathways. This has led to retrofitting of the pathways at some locations and to the modification of certain regulations to cater for the sharing of space among pedestrians and cyclists.

Following this introduction, the current paper depicts planning and spatial characteristics of Singapore, with focus on facilities shared among pedestrians and cyclists – Section 2. Then, findings from a small case study are presented to illustrate users’ travel behaviour, attitudes towards walking and cycling, and active mobility demand at locations with shared pedestrians and cyclists’ facilities – Sections 3. Afterwards, impetus for planning and management standards, including policies that can help to further increase usage of active modes are discussed and a holistic conclusion is provided – Section 4.

2. Planning and spatial characteristics in Singapore

In just over 50 years, Singapore is not only recognised as a ‘Garden City’, but also as one of the economic and political centres of the Asian continent. Given the limited land space and continual growing population (projected to reach 6.9 million habitants by 2030 (Cheam, 2013)) rigorous planning has always been required. This helped to ensure efficient maximisation of space usage. Urban planning in the country is performed in two main streams: residential and urban planning, and transport and green spaces planning. The urban planning success in Singapore, which has been internationally lauded, is due the integrated foresight method and undeviating implementation (Meng et al., 2015). Several agencies work in tandem to ensure all needs are considered, such as the Urban Redevelopment Authority (URA), the Land Transport Authority (LTA), and the Housing Development Board (HDB).

A scientific and rigorous framework consisting of three layers of planning is used (see Figure 1) (Meng et al., 2015; Tay, 2009). The highest level is locally known as “concept plan”. A 40 to 50 years’ plan – reviewed every 10 years, ensures sufficient land space is available to meet the population requirements and economic growth. Then, the “master plan”, a 10 to 15 years’ plan – revised every 5 years, designates land-use pattern and transport network layout. Finally, the “detailed plan”, usually a 5 to 10 years’ plan, considers near-term developments (Tay, 2009). In the master and detailed plan public housing programme, conservation of green spaces policies, financial support policies and transport usage policies are carefully designed for implementation without bias. Needs and preferences of the multi-racial population in Singapore are considered at each level of planning. Public participation are a key element of each step (Bin, 2013).
To develop the ‘Garden City’, the ring concept was introduced back in 1970s, with residential towns (of different densities), industrial areas and commercial centres organised surrounding a central water catchment, all interconnected by a comprehensive road network and mass rapid transit (MRT) system (MND, 2013). Later, to achieve further decentralisation (i.e. to avoid segregation of activities) and reduce trips lengths, the country was divided into five main regions (see Figure 2). Specific land use is planned in accordance to the town’s topology. Infrastructure is deliberated based on number of inhabitants to develop a ‘MRT-centric’ town with 1/3 high-rise residential buildings, 1/3 commercial, industrial and educational infrastructure, and 1/3 transport and green space (MND, 2013). Towns are self-contained, yet connected by comprehensive public transport system and road network. The efficiency of public transport resulted in a high usage of MRT and buses (63% usage as of 2013) (CLC & ULI, 2015; Meng et al., 2014).

2.1. Transport planning and policies

Transport planning and management has always received ample attention. The transport network links towns with each other and with the city centre. Roads are organised in a hierarchical manner as shown in Figure 3, with a layout that not only enhances connectivity but also serves as a traffic calming alternative.
The expressway is at the outermost of the towns, major arterials link the town centre with the outside network while minor roads provide connection between the main buildings within the towns (LTA, 2016b). In addition, an extensive network of pathways is provided alongside mayor and minor arterial roads.

Figure 3. Road System in Singapore (Adapted from Liu, 2014)

The 155 km length MRT line (LTA, 2015b) goes through the towns, and commercial activity centres are located in/near the MRT stations. Also, a (mostly feeder) public bus system is available for shorter-range trips between stations and residences. The cost for this service is determined based on distance-fare from 0.79 to 2.67 SGD (0.57 to 1.92 USD approx.), fare is based on total travelled distance regardless the number of transferred stations or modes (MOT, 2012). Provision of MRT and stations are planned according to population level at different towns (Meng et al., 2014). By 2030, LTA aims to reach 360 km length of rail. By then, 80% of the population will live within 10 minutes’ walk from a MRT station (MND, 2017).

Public transport is a widely selected mobility alternative in Singapore, mainly due to its convenience and accessibility. There are many policies that favours public transport usage (e.g. provision of bus lanes, ‘Give Way’ to bus signal, express bus services, intra-town services, night bus services (Ibrahim, 2003) and/or various measures that discourage private transport usage (e.g. Electronic Road Pricing (ERP), and Certificate of Entitlement (COE – vehicle quota system to manage vehicle population) (Ibrahim, 2003; Meng et al., 2014)). Singapore is also advocating efforts to promote the usage of active modes of transport and thus become a ‘car-lite’ country.

2.1.1 Active mobility planning and policies

Walking and cycling facilities are being expanded in Singapore. For pedestrians, pathways, crossings and overhead bridges are common infrastructure. Shelters are also provided at areas with high levels of pedestrian traffic (Chin & Menon, 2015). Herein, the focus of this discussion shall be on the cycling facilities that are shared among pedestrians and cyclists. According to latest statistics, cycling takes up between 1% to 2% as a principal mode of transport (Cheong, 2016a). Previously, planning and management of cycling was mostly focused on recreational cycling. Cycling “resurfaced” after a period of unpopularity with the implementation of the Park Connector Network (PCN) in 1992. Today, the PCN has 400 km length and it is much used for cycling, walking, exercising and other recreational activities (Tanuwidjaja, 2011).

Bicycle parking lots are available at most MRT stations, where the number of lots is dependent on demand (Cheong, 2016c). Developers are also required to consider safety, convenience and accessibility for
pedestrians and cyclists, to increase usage of these modes and minimise conflicts among different users (URA, 2016). Furthermore, dock-less bicycle sharing system is being pilot tested in the country (Cheong, 2017). Efforts to make active modes viable options for short- and first/last-mile-trips are tireless, with most of recent developments being focused on cyclists.

Previously, cyclists were only legally allowed on pathways at “cycling towns” and at PCNs. However, bicycles and lately also other PMDs, frequently ride on pathways. This called for a review of the regulations. Today, a set of rules and codes of conduct for usage of bicycles and PMDs (e.g. kick-scooter, hoverboards, unicycles, etc. – excluding electric bicycles) on pathways has been recommended, and shall be legalised in due course. A maximum speed limit of 15km/hr at pathways and 25km/hr at shared paths has been recommended. Other recommendations include right-of-way, consideration for other users and movement direction (Cheong, 2016b). These rules and codes of conduct shall help to increase safety and reduce conflicts among mixture of various users. However, to establish clear planning and management standards, it is important to understand actual perception and behaviour of users.

As the number of recreational and utilitarian cyclists increases rapidly, authorities started developing off-road cycling facilities in earnest (see Table 1). Today, 11 residential towns are known as “cycling towns”. These are equipped with intra-town cycling networks (approx. 300 km length), comprising demarcated cycling paths and stretches of pathways that have been widened from 1.5 to 2 metres. These features promote greater shared-usage among pedestrians and cyclists and increase safety. Other towns are being upgraded so that by 2030 all towns are equipped with cycling networks (LTA, 2016a). Although demarcated, spaces are commonly shared between pedestrians and cyclist. To the date, not many have reported the impact of shared spaces in travel behaviour, attitudes towards active mobility, and active mobility demand. Thus, to gain better understanding about these points and estimate the relationship between users’ needs and shared spaces actual operating conditions a case study was conducted.

<table>
<thead>
<tr>
<th>Facility</th>
<th>Shared paths</th>
<th>Dedicated paths</th>
<th>PCN</th>
<th>Parking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Picture</td>
<td></td>
<td>Segregated path</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traditional path</td>
<td>Traditional paths (1.5mtrs wide) &amp; extended paths (2mtrs wide) shared by pedestrians, cyclists &amp; other PMD users. Pedestrians have the right of way. Maximum speed limit 15km/hr</td>
<td>Segregated or demarcated paths were each user has their right of way. Maximum speed limit 20km/hr</td>
<td>Wider paths used by pedestrians, cyclists &amp; other PMD users mostly for recreational activities – Shared at some locations and dedicated at others.</td>
<td>Available at most MRT stations and some recreational locations. Parking at MRT station is provided based on the traffic at each station. These are inverted “U” shape, double decker, etc.</td>
</tr>
</tbody>
</table>
3. Case study

To study travelling characteristics and behaviour at shared spaces, naturalistic observation and interview surveys were conducted in two cycling towns in Singapore. Observations allowed us to gain deeper understanding of pedestrian and cyclists interactions and determine most suitable survey locations. Overall, it was observed that at cyclists park their bicycles outside designated parking areas, the number of active mobility users was higher at sheltered locations, which is attributed to weather factors, and at PM peak hours many “recreational” cyclists were observed (assumed to be recreational as they were cycling at parks, off-peak hours, and at a relatively slow pace). These observed factors were added as options for motivations to increase cycling and as possible reasons not to do it in the survey questionnaire.

At a second stage, road users were randomly approached at different locations within these two towns and invited to participate in the interview survey. Sembawang and Yishun where the selected residential cycling towns. These towns are adjacent to each other and considered mature cycling towns as the provision for bicycles has been completed more than a two years ago and there are no plans for immediate improvement of the cycling network. Sembawang and Yishun are mostly residential towns and have 10.7km and 15.5km of intra-town cycling paths respectively.

Users who agreed to participate were asked to complete a comprehensive survey questionnaire. The questionnaire was mainly focused on commuting behaviour and cycling perception. It was aimed to understand the effect of cycling infrastructure on bicycle usage and overall active trips. The survey also included questions to estimate respondents’ awareness of cycling infrastructure in the town, reasons for cycling (or not) at the cycling town, and cycling frequency with respect to perceived characteristics of the paths. Demographic information of the participants was also collected. Surveys were conducted during weekdays at peak periods to capture as many participants as possible. Prior to actual data collection, a pilot test was conducted to ensure efficiency of each question and to provide guidance in training interviewers.

3.1. Sample characteristics

Of the survey participants, 202 were residents or frequent visitors of the cycling towns under study, 61% and 39% respectively. Answers provided by these participants were analysed for this case study. They were interviewed at different locations over the cycling towns while commuting as pedestrians (73%) or cyclists (27%). Regarding gender split, slightly more males (57%) participated of the survey. Most of them were young adults (20-29 years old – 24%) and adults (30-39 years old – 32%) and approximately 10% correspond to each of the remaining age groups (i.e. 10-19 years old, 40-49 years old, 50-59 years old, and ≥60 years old). In line with this age distribution, 66% of the participants were employed, 17% students and 17% housewives, unemployed or retired. Almost all survey participants (91%) have lived in Singapore for at least 5 years.

More than half of the participants reported to cycle on a regular basis (46% at Sembawang and/or Yishun and 7% elsewhere) and 8% reported intentions to shift to cycling. The remaining reported not to cycle and no intentions to become cyclists. Interestingly, 3 every 4 households of the surveyed participants owned some type of bicycle (adult bicycle, children bicycle, and/or electric bicycle). The elevated rate of bicycle ownership is attributed to the fact that cycling activities are quite prominent at residential cycling towns. The average number of bicycles at those households equal to 1.7 (max 6; min 1). Moreover, few households (7%) owned other type of PMD. Yet, given the recent surface of these devices, this percentage can be considered high. Demographic and transport characteristics of the respondents are summarised in Table 2.

Page 6 of 14
Table 2. Respondents demographic and transport characteristics

<table>
<thead>
<tr>
<th>Respondents</th>
<th>National proportion*</th>
</tr>
</thead>
<tbody>
<tr>
<td>n=202</td>
<td></td>
</tr>
<tr>
<td><strong>Cycling town residents</strong></td>
<td>61%</td>
</tr>
<tr>
<td><strong>Cycling town frequent visitors</strong></td>
<td>39%</td>
</tr>
<tr>
<td><strong>Males</strong></td>
<td>57%</td>
</tr>
<tr>
<td><strong>Pedestrians</strong>*</td>
<td>73%</td>
</tr>
<tr>
<td><strong>Cyclists</strong>*</td>
<td>27%</td>
</tr>
</tbody>
</table>

**Age**

<table>
<thead>
<tr>
<th>Age</th>
<th>Respondents</th>
<th>National proportion*</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-19 years old</td>
<td>11%</td>
<td>22% (0 to 19 years)</td>
</tr>
<tr>
<td>20-29 years old</td>
<td>24%</td>
<td></td>
</tr>
<tr>
<td>30-39 years old</td>
<td>32%</td>
<td></td>
</tr>
<tr>
<td>40-49 years old</td>
<td>12%</td>
<td></td>
</tr>
<tr>
<td>50-59 years old</td>
<td>11%</td>
<td></td>
</tr>
<tr>
<td>≥60 years old</td>
<td>10%</td>
<td></td>
</tr>
</tbody>
</table>

**Employment**

<table>
<thead>
<tr>
<th>Employment</th>
<th>Respondents</th>
<th>National proportion*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employed</td>
<td>66%</td>
<td>61%</td>
</tr>
<tr>
<td>Students</td>
<td>17%</td>
<td></td>
</tr>
<tr>
<td>Housewife/Unemployed/Retired</td>
<td>17%</td>
<td></td>
</tr>
</tbody>
</table>

**Cycling frequency**

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Respondents</th>
<th>National proportion*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regularly (&gt;1 per week)</td>
<td>26%</td>
<td></td>
</tr>
<tr>
<td>Occasionally (&lt;1 per week)</td>
<td>20%</td>
<td></td>
</tr>
<tr>
<td>I don’t cycle in [cycling town], but I cycle elsewhere</td>
<td>7%</td>
<td></td>
</tr>
<tr>
<td>I don’t cycle but I plan to start cycling</td>
<td>8%</td>
<td></td>
</tr>
<tr>
<td>I don’t cycle and I don’t plan to start cycling</td>
<td>39%</td>
<td></td>
</tr>
</tbody>
</table>

**Bicycle and other PMDs ownership**

<table>
<thead>
<tr>
<th>Ownership</th>
<th>Respondents</th>
<th>National proportion*</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1 or more bicycles or PMDs in the household)</td>
<td>78%</td>
<td></td>
</tr>
<tr>
<td>Adult bicycle</td>
<td>73%</td>
<td></td>
</tr>
<tr>
<td>Child bicycle</td>
<td>9%</td>
<td></td>
</tr>
<tr>
<td>Electric bicycle</td>
<td>1%</td>
<td></td>
</tr>
<tr>
<td>Other PMDs</td>
<td>3%</td>
<td></td>
</tr>
</tbody>
</table>

**Vehicle ownership**

<table>
<thead>
<tr>
<th>Ownership</th>
<th>Respondents</th>
<th>National proportion*</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1 or more cars/motorcycles in the household)</td>
<td>38%</td>
<td></td>
</tr>
<tr>
<td>Car</td>
<td>36%</td>
<td></td>
</tr>
<tr>
<td>Motorcycle</td>
<td>3%</td>
<td></td>
</tr>
</tbody>
</table>

*At the time of the interview

3.2. Travel behaviour

The survey questionnaire was aimed to gain a deeper understanding of users travel behaviour at shared spaces, focus was placed on cyclists. Survey participants were asked to select their most commonly used mode of transport between MRT, public bus, private transport, walking, cycling and other modes (e.g. PMDs, taxi, etc.). Public transport was the main mode of transport used by most of the respondents (54%) (34% MRT and 20% public buses), 13% mostly use private transport, 21% mostly commute as pedestrians, 10% mainly cycle, and a small 2% use other modes of transport (see Figure 4). In addition, as previously mentioned, more than half of the participants reported to regularly cycle at the towns analysed in this case study (as main or secondary mode of transport). The elevated bicycle usage indicates that indeed cycling is more popular at these towns as compared to the average 1-2% cycling (as main mode) in the country.
Demarcated cycling paths were implemented in Sembawang and Yishun in 2013 and 2015, respectively with aims to enhance comfort, safety and accessibility of cycling trips (LTA, 2015a). Of the 202 survey participants, 111 or 55% reported to be aware of these demarcated cycling paths. Interestingly, many of these (33) do not cycle. Indicating that besides cyclists, who obtain most benefits from the paths, pedestrians also enjoy (and most likely use) demarcated cycling paths in the towns under study. More specifically, perception of the cycling network was found to be positive among cycling towns residents. Seven in ten residents (n=123) reported being aware of the demarcated cycling paths. However, opposite is true for frequent visitors. Only one in five town frequent visitors answered positively about awareness of the cycling network. Although many reported to be aware of the cycling paths, more can be done to increase awareness. Authorities could focus further in advertising about paths locations and characteristics. Alternatively, paths can be modified so that they become more obvious to users. For instance, these can be painted of different colours (currently they are the same as normal pathways) or equipped with clearer signals for specific users.

A section of the questionnaire was intended to assess changes in transport usage and its relationship with provision of shared facilities. First, respondents who reported to cycle at Sembawang/Yishun (n=93) were asked to state the year they started cycling. Using these dates and the implementation of cycling network dates it was found that one third started cycling after the implementation of the cycling network. Suggesting that provision of infrastructure increased cycling demand. This can be considered at planning level to estimate possible increase in active trips based of type of infrastructure provided.

Then, cyclists’ participants were inquired about their cycling frequency at the cycling towns and pedestrians their willingness to undertake more cycling trips. Of the total survey participants, 26% cycle regularly (once a week or more), 20% cycle occasionally (less than once a week) and 109 or 54% respondents do not cycle at the cycling towns under study, of whom 14 reported to cycle (and stay) elsewhere. Of the pedestrians, who currently do not cycle at all (n=95), around one in five reported willingness to start cycling in the near future. Being their top 3 motivation for doing so: (1) Because it is convenient – 26%, (2) for health or recreation – 21% and (3) because if saves time and money – 21%. Enhanced safety was the next mentioned motivation. Surprisingly, very few participants reported willingness to undertake more cycling trips because of better cycling infrastructure – 5% (see Figure 6a). Respondents provided no more than 3 motivations. It is worth mentioning that of those willing to shift, only 2 were aware of the demarcated paths available for cyclists in the towns under study.

*Source: LTA Statistics in Brief 2015*
Contrastingly, the remaining four in five (n=78) of these pedestrians reported being unwilling to start cycling – “I do not cycle and have no plans to start cycling in the near future”. Of these, only two in five reported to be aware of the demarcated paths in the towns. Thus, as mentioned, if more advertising campaigns were available and/or if paths characteristics were more prominent, demand, not only for cycling but also for other active modes of transport, is likely to increase. Top unwillingness to start cycling included: (1) distance (I go to places too far or within walking distance) – 19% (2) feeling of insecurity related to traffic safety and convenience of public transport – 14% each, and (3) weather factors (too hot/too rainy) – 12%.

3.3. Transport usage

Implementation of demarcated cycling paths appeared not to caused much modification in usage of motorised modes of transport, walking and usage of PMDs. However, a change in cycling was reported. On average, seven in ten participants, who reported being aware of the demarcated cycling paths (n=111), reported to use motorised modes, walking, and PMDs the same as before the implementation of the cycling paths. Although minimal, more people reported reduced usage of motorised modes and increased usage of active modes, suggesting that overall designated cycling paths increase demand for active mobility. Responses are illustrated in Figure 5.

Figure 5. Change in demand for different modes of transport after implementation of cycling network

About cycling, half of the respondents, who were aware of the cycling paths, reported to undertake cycling trips more frequently as compared to before the implementation of the paths. As for those who reported willingness to undertake cycling trips in the near future, the actual reason for doing so was asked to those who “currently cycle more”. Interestingly, the top 3 motivations and reasons reported are the same, but with slightly different percentages. Being the reasons: (1) because it is convenient – 32%, (2) because it saves time/money – 21%, and (3) for health/recreational reasons – 19%. On the other hand, reason for not cycling more were asked to those who reported to cycle same or less after the cycling paths implementation. They were given same possible reasons for not to cycle more as those who reported not to have plans to start cycling in the near future. The most common reasons for not cycling more are: (1) because they did not recognize the improvement – 27%, (2) lack of parking and/or end of the trip facilities – 16%, and (3) too long or too short travel distance – 13%.

Interestingly, the overall stated reasons for increasing cycling in the future and the actual reason for increased cycling trips are not very different. Being the most differences noted at “Because is convenient”
and “For an environmental cause” Users who cycle tend to give more weightage to convenience and those who are willing to start cycling are more likely to do it so because of shifts to sustainability and “green” or active modes of transport. For those who are unwilling to start cycling or cycle more than before, some more differences can be noticed (see Figure 6a and 6b). Two interesting points can be highlighted about these reasons. First, none of the respondents (not pedestrians nor cyclists) reported sharing issues as deterrents for cycling. Although traffic safety concerns were mentioned, this was mostly related to high speed traffic at adjacent roads and concerns at crossings. Second, very few people mentioned improvement of the network (better cycling infrastructure) as main reason to cycle more. Moreover, many reported not to recognise the improvement and lack of end-of-the-trip facilities as reasons for not cycling more.

Figure 6. Willingness and actual reasons to cycle more/same/less

3.3. Shift-rate

Participants who reported increased cycling trips (n=63) were asked to recall their cycling trips currently and how were these trips made before the cycling paths implementation. Although participants were asked to
report all their cycling trips, most people only reported one and maximum two trips. Presumably their most common cycling trip(s). A total of 100 current cycling trips were reported. Almost all these trips were home-based two-way trips, being the most common reasons: (1) to commute to work/school – 32%, (2) leisure/exercise – 22%, and (3) as first/last mile trips to reach other modes of transport – 19%.

Of the 100 cycling trips, 78 of them shifted from other modes. Interestingly, majority shifted from walking (37). Thus, although an increase in cycling, it does not indicate an increase in overall active mobility demand. Regarding shifts from motorised modes, most people shifted from bus (28). Only few trips shifted from MRT or private transport, 4 and 3 respectively. To estimate the shift-rate from motorised modes of transport, the methodology used by Nguyen and colleagues can be utilised (Nguyen et al., 2015). Their study analysed shift rate to cycling at Tampines residential cycling town in Singapore at different time periods. Following their methodology, first the proportion of cycling trips shifted from different modes is calculated as shown in Equation 1 to 3.

\[
b = \frac{\text{No. of reported cycling trips shifted from bus}}{\text{Total no. of reported cycling trips}} = \frac{28}{100} = 0.28 \quad \text{(Equation 1)}
\]

\[
m_{\text{RT}} = \frac{\text{No. of reported cycling trips shifted from MRT}}{\text{Total no. of reported cycling trips}} = 0.04 \quad \text{(Equation 2)}
\]

\[
c = \frac{\text{No. of reported cycling trips shifted from private vehicles}}{\text{Total no. of reported cycling trips}} = 0.03 \quad \text{(Equation 3)}
\]

Then, these proportions and the total number (assuming it is known) of daily trips by these modes of transport in the town are used to estimate the actual shift rate to cycling by:

\[
\text{Shift rate from bus to cycling} = \frac{b \times \text{Cycle}}{\text{Bus}} \quad \text{(Equation 4)}
\]

\[
\text{Shift rate from MRT to cycling} = \frac{m_{\text{RT}} \times \text{Cycle}}{\text{MRT}} \quad \text{(Equation 5)}
\]

\[
\text{Shift rate from private transport to cycling} = \frac{c \times \text{Cycle}}{\text{Private transport}} \quad \text{(Equation 6)}
\]

where \(\text{Cycle, Bus, MRT, and private_transport}\) represent the total number of daily trips by each of these modes of transport in the town. These shift rates can be applied using the overall town/country statistics such as Household Interview (Travel) Survey.

4. Discussion and conclusion

Given Singapore's admirable and rigorous urban and transport planning, (limited) available land use is maximised while at the same time catering for population requirement and economic growth. With the recent push to become a 'car-lite' country, the usage of active modes of transport is being promoted. Thus, authorities are currently focused in providing suitable infrastructure to ensure comfort, safety and accessibility of active mobility users. Among other approaches, authorities have equipped several towns in Singapore with cycling networks – that are commonly shared among pedestrians and cyclists. This study is
placed in two cycling towns in Singapore (Sembawang and Yishun) and it analyse travel behaviour, attitudes towards active modes, and active mobility demand.

Regarding travel behaviour, the usage of public transport and walking is quite similar at cycling towns as compared to the national rates. However, a lower usage of private transport and an increased usage of bicycles was reported. The case study also shed light into PMDs usage, which has not been reported in national surveys. Around 2% of the participants mostly commute by PMDs. Based solely in these rates, it can be concluded that infrastructure provision for cycling increased usage demand of bicycles and other PMDs. Indeed, when asked about modifications of their travel behaviour after the implementation of the demarcated paths, majority reported increased cycling trips, and although minimal, some reported increased trips as pedestrians and PMDs users and reduced usage of motorised modes.

Moreover, among town residents, positive awareness about the infrastructure provision was found and negative awareness was found among frequent visitors. This lead to recommendations to further advertise characteristics and locations of the paths and/or provide the paths with more striking characteristics so that these are clearly noticed by everyone.

Interviewed pedestrians who reported not to cycle were asked to report their willingness (or not) to take more cycling trips in the future and reasons for doing so. Of these, only one in five reported willingness to start cycling in the future and the remaining four did not. Willingness to shift (or not) reasons were compared with reasons for actual increase (or reduction) in cycling demand after the implementation of the paths. Interestingly, pedestrians who are considering cycling in the future and cyclist who reported to cycle more after the implementation of segregated paths, mentioned the same reasons for doing. Yet, some differences were found among pedestrians who are not willing to start cycling and cyclists who reported to cycle the same or less as they did before the implementation of the paths. Cycling trips before and after the implementation of the paths were described. It was found that most trips shifted for walking. Reported usage before and after was used to calculate shift proportion. These proportions can be used to estimate overall shift rate using overall town/country statistics such as Household Interview (Travel) Survey.

Top reasons for cycling more (actual reasons or stated preferences) are: because cycling is convenient, because it saves time and money, and for health or recreation. Convenience can be associated with the implementation of the cycling network which most likely made trips more comfortable and accessible. However, not many directly mentioned infrastructure improvements as reasons to shift to or increase cycling. Consequently, it can be said that although users do might not perceived actual improvement as reasons to increase cycling, consequences of it does. Increased safety was also mentioned as a factor to increased cycling after the implementation of the cycling network. Safety can also be considered as an effect of the demarcated paths implementation.

Regarding reasons for not cycling more, distance limitations, convenience of public transport, and safety concerns were most commonly mentioned by pedestrians who do not consider cycling. Distance was also mentioned as a reason not to cycle more by current cyclists. This was mentioned right after “I did not recognise the improvement” and lack of parking/end-of-the-trip facilities. Perceived distance limitations could be overcome by advertising how provision of cycling paths makes cycling more accessible and different locations are easier to reach by using bicycles. Increased advertising can also help to increase awareness of the paths and thus increase cycling demand. As mentioned previously, public transport is very convenient indeed, especially due to the distance-based fare. Thus, not surprisingly these modes of transport (specially buses) compete with active mobility for some trips. Authorities should consider the benefits of each modes usage and in due case review the distance-based fare to further increase active mobility demand. Regarding safety, further research should be focused on understanding users’ interaction and actual type of conflicts so
that paths characteristics can be modified and/or to incorporate devices, such as traffic calming (e.g. features that cause cyclists to slow down) and off-road traffic signals, to increase safety levels.

Finally, future stages of research, will also focus on impacts of cycling facilities on walking trips and usage of the facilities by different users’ groups (e.g. different ages, gender differences, etc.). Also, the different types of conflicts can be further study to provide alternatives to reduce accidents risks. Considering these factors the overall active travelling experience in Singapore can be improved.

Acknowledgements

This study is conducted as part of first author’s PhD research project; the research is supported by Mitsui Sumitomo Insurance Welfare Foundation Research Grant 2016 and by Singapore Ministry of Education Academic Research Fund Tier 2 MOE2014-T2-2-097. The authors would like to thank to undergraduate students’ helpers who contributed in data collection and data extraction.

References


