Making the train: Re-conceptualising accessibility for intra-urban rail travel

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Abstract

Australian authorities have set ambitious policy objectives to shiftAustralia's current transport profile of heavy reliance on private motor cars to sustainable modes. Improving accessibility of public transport is a central component of that objective.Past studies on accessibility to public transport focus on walking time and/or waiting time. However, travellers' perceptions of the interface leg journeys may depend not only on these direct and tangible factors but also on social and psychological factors. This paper extends previous research that identified five salient perspectives of rail access by means of a statement sorting activity and cluster analysis with a small sample of rail passengers in three Australian cities (Zuniga et al, 2013). This study collects a newdata set including 144 responses from Brisbane and Melbourne to an online survey made up of a Likert-scaled statement sorting exercise and questionnaire. It employs factor analysis to examine the statement rankings and uncovers seven underlying factors in the exploratory manner, i.e., station, safety, access, transfer, service attitude, traveler's physical activity levels, and environmental concern. Respondents from groups stratified by rail use frequency are compared in terms of their scores of those factors. Findings from this study indicate a need to re-conceptualize accessibility to intra-urban rail travel in agreement with current policy agenda, and to target behavioral intervention to multiple dimensions of accessibility influencing passengers' travel choices. Arguments in this paper are not limited to intra-urban rail transit, but may also be relevant to public transport in general.

1. Introduction

In an effort to improve intra-urban mobility and to simultaneously decrease reliance on private car travel, transport-planning research has taken two divergent paths regarding public transport – both emphasizing accessibility as their core concept. One path has emphasized large-scale, geographic measures of accessibility, which relate to the availability of rail system infrastructure to meet potential trip demand(see, e.g., Vandenbulcke et al., 2007) and conceptualise public transport as a government provision to support social inclusion.The other main path emphasizes mode choice and identifies factors that serve either as facilitators or barriers to ridership. While most studies have focused on physical and technical factors that influence station 'access', some have suggested additional dimensions of accessibility that might begin to explain low public transport mode share in places with physical infrastructure in place(see, e.g., Beimbornet al., 2004; Zuniga et al., 2013).

This paper explores dimensions of accessibility to urban rail transit from the passengers' points of view. Data include 144 responses from Brisbane and Melbourne to an onlinesurvey made up of a Likert-scaled statement sorting exercise and questionnaire. The study employed an exploratory factor analysis to examine statement rankings and uncoveredseven underlying factors. Respondents from different groups by rail use frequency were compared in terms of their factor scores. The paper concludes with discussion of policy implications. Arguments in this paper are not limited to intra-urban rail transit, but may also be relevant to public transport in general.

2. Literature Review

Aiming to support social inclusion, to enhance the efficiency of intra-urban mobility and to decrease private car use and dependence, transport-planning research has undertaken to investigate public transport at two scales and through different conceptual lenses – while emphasizing accessibility as a shared core concept.

A significant body of literature focuses on the availability of the public transport network to meet potential trip demand(e.g., Burns, 1979; Dalvi& Martin, 1976; Giannopoulos &Boulougaris, 1989; Morris et al., 1979), measuringaccessibility geographically (Ben-Akiva&Lerman, 1979), and system capacity at a large scale.That discourse emphasizes the degree to which public transport infrastructure facilitates its use, and is geared towards a conceptualization of public transport as a benefit that is provided (or heavily subsidized) by the government to support social inclusion.

In contrast, another substantial body of literature focuses on factors associated with transport mode choice, often using customer satisfaction as a proxy for current passengers' inclination to continue or increase ridership. Although that discourse is geared towards a conceptualization of public transport as a commodity that must be marketed to potential customers, it largely measures accessibility in terms of passengers' perceived ability to get from the end-points of the overall journey to and from public transport facilities (e.g. stops and/or stations) (see, e.g., Kittelson& Associates et al., 2012).

Although that discourse is geared towards a conceptualization of public transport as a commodity that must be marketed to existing and potential customers, it largely measures accessibility (or access) in terms of passengers' perceived or actual physical ability to get from the end-points of the overall journey to and from public transport facilities (e.g. stops and/or stations). For example, several studies have identified significant concerns related to the time, effort and convenience of getting to public transport in the first place(Brons et al., 2009; Givoni&Rietveld, 2007), suggesting that to compete with automobile travel, public transport providers should treat the experience as a chain of trips that encompass the entire door-to-door journey (Iseki & Taylor, 2010; Litman, 2011; Wardman, 2004). In fact, studiesindicate that travellers consider the leg journeys between a trip's end-points and the transit vehicle to be more burdensome than the in-vehicle journey (e.g., the high value of time with respect to access/egress walking time and waiting time, see Balcombe et al., 2004; Litman, 2011; Kittelson& Associates et al., 2003).

Although the majority of mode choice research acknowledges personal characteristics of passengers as significant control variables, only a few researchers have specifically examined differences in passengers' perceptions of rail travel. In an effort to guide travel behaviour intervention, some

researchers have used market segmentation techniques to identify patterns of personal characteristics that correspond to various mode choices and other behaviours and perceptions (see, e.g., Anable, 2005; Bachand-Marleau, 2005; Beirao& Cabral, 2008). For example, Zuniga et al. (2013) used a statement sorting technique and applied case-wise cluster analysis to identify five types of rail passengers among a small sample of respondents, who varied in their frequency and location of rail travel as well as certain socio-demographic characteristics.

Several studies of travel behaviour have discussedmultiple dimensions of accessibility that might begin to explain the low public transport mode share in places with physical infrastructure in place. These include physical access,temporal access, financial access, cognitive or psychological access,social access, and affective access(Beimbornet al.,Blainey et al., 2012; Börjessen, 2012;Cass et al., 2005; Geurs& van Wee, 2004; Zuniga et al., 2013).

Reinforcing the implied subjectivity of rail accessibility, the various dimensions of access are also used to describe potential barriers to rail travel. In a review of transport literature, Blainey et al. (2012) grouped 37 finer dimensions of rail access into three types of barriers. The first type was described as hard barriers (included in conventional transport demand models and straightforward to measure or estimate). The second type was described as soft barriers (specific and/or of varying importance to particular travellers, trips, and places). The third type was described as complementary (or lifestyle) barriers (not directly relating to mode quality, but instead to the impact on travel choices of activity and lifestyle choices and vice-versa, and wider cultural and economic factors). Blainey et al. (2012) noted that the impacts of softer and complementary barriers have been more difficult to measure and/or estimate.

Although transport-planning literature recognizes multiple dimensions of accessibility, it has generally emphasized the more readily measurable factors influencing geographic availability and ridership, with less discussion of passengers' subjective interpretations. In this paper, we begin to address that shortcoming byinvestigating passengers' subjective interpretations of accessibility as it relates to their individual travel choices.

3. Methods

3.1 Research Setting

Melbourne is a city of 3.6 million people with a public transport system consisting of trains, trams and buses. 13% of all motorised trips are bypublic transport. There are approximately 450 million annual boardings on Melbourne's public transport system overall and 201 million on the metropolitan railway. The rail system is radial to the CBD and includes 15 lines across two fare zones: an outer and an inner zone concentric to the CBD. Between 1993/4 and 2007/8 the number of rail trips has doubled with a 43% increase in ridership over the last 5 years. More recently rail patronage has levelled off (Currie, 2011).

Brisbane's metropolitan area has a population of 2.2 million, and the SEQurban conurbation centring on Brisbane encompasses a population of more than 3 million. Public transport in SEQ is provided by bus, rail and ferry services. The urban rail network consists of 10 suburban lines. Queensland Department of Transport and Main Roads' TransLinkDivision provides a platform for the integration of the public transport system in SEQ. As indicated in 2006 Census data, the use of urban public transport in SEQ is still only a small component (7%) of total passenger transport, the largest component (83%) being travel by private car. The patronage on public transport has increased by 45% – from 120 million annual boardings in 2003–04 to about 175 million annual boardings in 2009–10. Among this, the annual patronage on rail has increased from 71.6 million in 2003-04 to 117.9 million in 2009-10(Queensland Government, 2011).

3.2 Data Collection

This study used an internet-based self-completion survey that included a statement sorting activity and short questionnaire. For this study, we made minor revisions to the survey used in the first stage of research (Zuniga et al. 2013), and distributed it electronically to a larger potential respondent pool. The online survey instructed participants to rank order a set of statements into a quasi-normalized distribution that ranged from most disagree (-4) to most agree (+4) (Figure 1). By imposing this distribution, the exercise compelled respondents to consider the statements in relation to each other, rather than rating them independently, and made it possible to evaluate each person's perspective as a whole in the original study. The survey also included a short questionnaire that captured socio demographic, household, and travel behaviour characteristics of the respondents. The web-based instrument was developed using FlashQ 1.0 (Hackert&Braehler, 2007) (see Figure 1).

Figure 1: Screen capture of statement sorting exercise

3.2.1 Statement set

The set of statements used for the sorting activity were developed, tested and refined through focus group discussions with frequent and infrequent rail passengers and a pilot statement sorting activity. To ensure that the statements reflected a broad range of issues, a factorial design was initially employed to include sixbroad topics (convenience, wellness, time, environment, social setting and danger), and ranging in scale from personal to general concerns.

3.2.2 Recruitment strategy

The respondent pool included two contrasting subgroups, sampled to test the analytical tool under divergent conditions. For the first sample, the research team invited students from two third-year undergraduate civil engineering classes in Brisbane to participate in an electronic version of the Q survey. Instructors subsequently discussed the methodology and students' experiences as research participants as part of their teaching. Participants ranged in their level of ridership but were otherwise relatively homogeneous in terms of age, education and socio-economic status. In total, 97 useful responses were received from the students.

For the second sample, the research team used an intercept approach to recruit participants at two CBD stations on the Melbourne urban rail network on the afternoons of 24 and 25 October 2012. Two surveyors approached passengers in the railway stations and briefly described the project before handing them a flyer stating the URL of the electronic survey and an opportunity to participate in a draw for one of several loaded fare cards. This resulted in a comparatively heterogeneous sample, stratified by several socio-demographic characteristics, including age, gender, and frequency of travel.

This recruitment strategy yielded 47 valid responses from 1000 distributed flyers. The quality of the 47 responses was very high. Almost all were completed, in an average time of about 30 minutes. To try to obtain sample's representativeness, the Melbourne Central Station was selected for the survey because it is the hub of Metro Trains network with all lines stretching out to surrounding suburbs. As the result, we obtained the 47 responses from passengers with their home stations located on 13 out of the 15 lines of Metro Trains network, with 23 in Zone 1 and 24 in Zone 2.

3.2.3 Participant profile

The overall participant sample obtained was composed of 47 females and 97 males, with a majority in the age group between 18 and 34 due to the University recruitment. Half (51%) of the overall sample had full-time jobs and most (70%) were full-time students. Most respondents (85%) had access to private cars, including all full-time employees. A summary of rail travel behaviour of the sample is presented in Table 2. The dominant access modes were car (40%, including 8% car passengers) and walking (40%), followed by bus or tram (18%) and bicycle (2%). The average access time was approximately 10 minutes for access modes of car and walking and 16 minutes for access by bus and tram. Regarding the egress journey, walking was the dominant mode (86%), followed by bus or tram (13%) and bicycle (1%). The average egress times of different modes were similar to corresponding average access times ranging approximately from 10 to 15 minutes except for bicycle access, which had a shorter egress time. Based on data acquired from the journey planner website of Melbourne's Metro Trains (MetroTrains, 2013) and Brisbane's Translink (Translink, 2013), we calculated that the average scheduled train time from home station to end station (i.e., the largest time for arriving before 9am on weekdays) was approximately 30 minutes. Moreover, OD distance and travel time by car were also estimated from Google Maps according to each respondent's reported street corners of their trip origin and destination.

A majority (88%) of participants used rail transit for the purpose of work or study. Almost 60% took the train more than three times per week. Most (75%) travelled by train alone, and some travelled with friends (18%). The majority (70%) of participants reported qualifying for concession fares.

Table 2: Respondents' travel behaviour

| Rail travel behaviour	Mode Split (%)	Average Access/Egress Time (min)	St. Dev. (min)
access from home to home station	car (40)	12.41	10.37
	walk (40)	11.57	7.08
	bus/tram (18)	14.50	8.65
	bicycle (2)	13.33	7.64
egress from end station to destination	walk (86)	12.81	7.94
	bus/tram (13)	17.05	10.87
	bicycle (1)	6.50	2.12
	Trip Direction	Average Value	St. Dev. (min)
Train waiting time (min)	at home station	9.77	7.15
	at end station	11.46	8.80
rail travel time (min)	from home station to end station	30.27	18.85
Car time (min)	Home corner to end corner	25.92	15.10
OD road distance (km)	As above	21.94	19.47

4. Analysis and Findings

4.1 Statement Rankings

The sample mean and standard deviation of the rating scores for each statement is listed in Table 3. Of those statements, only #36 ("Public transport is mostly for poor people") and #21 ("I always choose the fastest way to my destination") obtained significant large average scores in magnitude over two. The sample average rating score seemed to show no distinctive perspectives on these statements. However, the relatively large statement ratings standard deviations indicated that a significant variationin perception among the sample.

Whisker-box plots of the ratings for the 36 statements illustrate the variations in statement ratings (see figure 2). For some statements in the middle section of Figure 4, the interquartile range was across the neutral point of zero with a relatively low standard deviation (e.g. +/- 1), which suggests that the statements did not elicit strong feelings of agreement or disagreement from a majority of respondents. In contrast, other statements with median scores near zero showed a larger standard deviation, eliciting much stronger responses of agreement or disagreement. For example, statement #4 ('Public transport is unreliable') had a broader interquartile range, which suggests that the topic was a priority to passengers, but that their subjective experience of the issue varies considerably. Further analysis should be conducted to reveal the more distinctive patterns of the statement ratings that reflect the respondents' perceptions of accessibility to rail stations.

Figure 2: Whisker-box plots of attitudinal rating scores of 36 statements
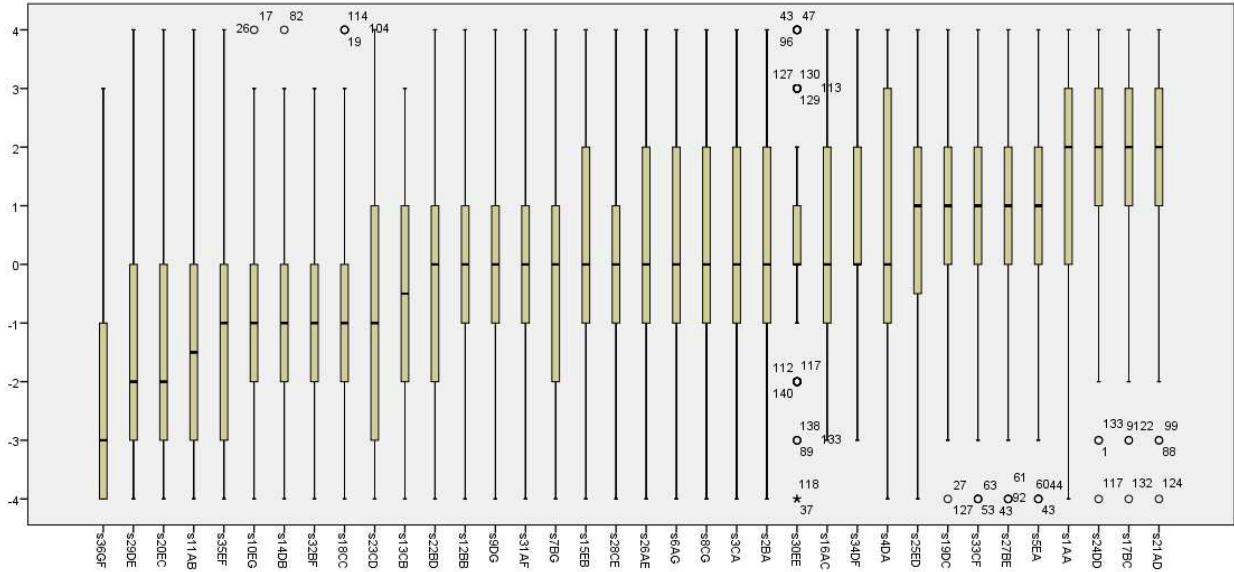
4.2 Explanations for Statements Eliciting Strong Responses

Each respondent was asked to comment on the statements with which he or she most agreed (with ranking score of +4) and disagreed (with ranking score of -4). Those comments were useful for understanding the respondent's subjective interpretations of various issues. Key themes included relative cost and wealth status, timing and reliability, environmental benefit, and personal convenience and comfort.

4.2.1 Theme 1 – Cost and status

Nearly one fifth (18.4%) of respondents strongly disagreed with statement 36 ('Public transport is mostly for poor people'). Qualitative feedback suggests three main subjective interpretations of that statement relating to city parking prices, the price of train fares, and the socio-economic status of rail passengers, which help to explain their prioritisation of the issue.

Table 3: 36 statements for sorting exercise with mean rating scores and standard deviations

Factor	ID	Statement	Mean	St. Dev.
Scheduling	1	I worry that I'll miss my train and be late to my destination.	1.37	1.93
Scheduling	2	I don't want to be tethered to timetables.	0.41	1.91
Scheduling	3	Coordinating transfers is difficult and annoying.	0.38	1.87
Scheduling	4	Public transport is unreliable.	0.51	2.42
Scheduling	5	Railway timetables are easy to find and understand.	0.93	1.97
Safety	6	I cannot safely leave my bike at a railway station.	0.33	1.65
Safety	7	I am intimidated by youths and strangers at railway stations.	-0.03	2.18
Safety	8	I feel safe travelling to and from the railway station.	0.35	2.08
Safety	9	There is too much road traffic around the railway station.	-0.11	1.75
Safety	10	Neighbourhoods near railway stations are safest.	-1.08	1.62
Convenience	11	It is easy to find a parking space at the railway station.	-1.44	2.07
Convenience	12	There is a lovely footpath leading to the railway station.	-0.22	1.69
Convenience	13	It is NOT a problem to carry heavy bags onto the train.	-0.67	1.84
Social Env.	14	Public transport staff and drivers are hard to understand.	-0.97	1.69
Convenience	15	Getting to the railway station is inconvenient.	0.03	2.04
Health	16	It is important to get exercise on the way to my destination.	0.47	1.64
Health	17	I don't want to be wet or smelly when I get to work.	1.85	1.49
Convenience	18	There are too many stairs to climb at the railway stations.	-0.85	1.77
Health	19	Public transport is a good place to catch an illness.	0.70	1.82
Social Env.	20	The railway station is a comfortable place to relax.	-1.62	1.74
Cost	21	I always choose the fastest way to my destination.	2.00	1.78
Cost	22	I can get work done at the railway station and on the train.	-0.50	2.16
Cost	23	It is cheaper to drive than to take public transport.	-0.72	2.31
Cost	24	I don't like to spend time at the railway station.	1.69	1.74
Cost	25	It is a waste of time transferring from the bus to the train.	0.67	1.91
Health	26	Bus and railway stations are dirty and smelly.	0.24	1.93
Phys. Env.	27	I'm concerned about air pollution caused by car traffic.	0.74	1.91
Social Env.	28	Affordable housing is located too far from railway stations.	0.23	1.80
Phys. Env.	29	Public transport is detrimental to the environment.	-1.70	1.90
Convenience	30	The climate here is ideal for rail travel.	0.45	1.63
Social Env.	31	I feel welcome and comfortable on public transport.	-0.08	1.87
Social Env.	32	I enjoy the energy and commotion of a busy railway station.	-0.91	1.74
Social Env.	33	Public transport staff and drivers are helpful and friendly.	0.74	1.74
Social Env.	34	Musicians and small vendors make rail stations enjoyable.	0.51	1.70
Social Env.	35	The railway station is a great place to socialize.	-1.38	1.49
Social Env.	36	Public transport is mostly for poor people.	-2.37	1.66

Bad traffic and expensive parking in the city

This explanation suggests that respondents view rail travel as a viable alternative for people of all economic classes who must enter the city centre regularly – and that those who work outside of the city may rely on car travel even if they are not well off. Some interpret city parking at out-pricing even those who might not otherwise be considered 'poor'. Since poverty and wealth are relative to the cost of goods, their response implies that parking costs are relatively high even after accounting for standards of living.

- Parking space in the city is extremely expensive not to mention petrol and the headache of traffic on your trip into and out of the city - public transport can be a convenient solution to everyone regardless of your income.
- It's good to avoid road traffic into the city and parking in the city is limited and expensive.

- Public transport is for everybody that doesn't want to be caught in traffic every morning or want to pay for parking and fuel at their destination.
- Whilst quite disadvantaged people and immigrants use PT as they have no viable alternative, many poorer people drive, typically as their jobs are not in the city.
- Many successful people take public transport because it is a quicker and less stressful commute to the city than driving and parking in peak hour conditions.
- No it is for everyone to use, especially where say driving to work is to difficult due to the amount of traffic on the roads.

Fare prices

Comments regarding fare pricing suggest that passengers do not view public transport as a provision to support social inclusion, but as a luxury for those who can afford it. This contrasts sharply with one of the two main conceptualisations espoused in the literature, and suggests that efforts to make rail services self-supporting diminish their social benefits.

- Public Transport is becoming too expensive for poor people!
- With increasingly expensive train fares, you would think that public transport was mostly for rich people.
- Why would it mostly be for poor people? Public transport in some cases would cost more than private transportation
- Adult fairs are ridiculously high.
- Any car with reasonable fuel economy is cheaper than public transport.
- The cost of PT is ridiculously high in Brisbane so that doesn't help.

Rich people also ride the train

At face value, this explanation only describes a broader socio-demographic profile of rail passengers. However, the fact that it is the explanation given for strongly prioritizing the response suggests a desire to validate the social status of rail passengers. The final statement regarding the 'success of a society' indicates a philosophical stance more than a neutral description of the social scene.

- It seems mostly to be well-dressed business people and students. The exception to this would be between 10:00 am and 2:30 pm, where I often see people less well off, though many can't afford tickets and are fined for fare evasion.
- I have been in a tram and train with CEOs of big companies, especially in the CBD area. They are not poor and still use public transport. However, the service is far from a premium service.
- The success of a society is not how many poor people have cars, but how many rich people take public transport.

4.2.2 Theme 2 – Timing and reliability

Approximately one eighth (12.2%) of respondents strongly agreed with statement 21 ('I always choose the fastest way to my destination').Explanations generally emphasized the desire to travel quickly and the means to accomplish that goal.

Reasons and means of decreasing travel time

These comments generally emphasize the significance of time, rather than providing additional interpretation. However, they do provide insight into the passengers' flexibility in terms of travel mode, since they are willing and able to switch to save time.

- This is important; I do not want to arrive late at my destination.
- I also want to get home quicker.
- I don't have time to waste.
- Don't like to spend unneeded time sitting on public transport, much rather spend it relaxing somewhere else.
- It is important to me that my trip is fast and efficient, I am not too concerned whether it is through public or private transportation.

- It is often faster for me to catch a bus or train rather than driving through peak hour traffic.
- I do not mind getting on and off trains often if it means getting the fastest train to my destination.

In contrast, a smaller proportion (8.3%) of respondents strongly agreed with statement 4 ('Public transport is unreliable'). In this case, the qualitative feedback suggested two main explanations for prioritising the statement including discrepancies between expected and actual departure times, and uncertainty due to fluctuations or poor information.

Off schedule (late or early)

These comments suggest a high degree of institutional knowledge regarding public transport, referring to typical system operations and their repeated failures. To gain that level of knowledge, respondents must have continued to use public transport despite the annoyance, which either implies that another factor outweighs reliability in importance, or that these are captive riders who do not perceive alternatives.

- Trains in the morning are delayed and overcrowded.
- Public transport is unreliable because they consistently run late.
- They also tend to run fairly late (compared to timetable) as well.
- Trains do not run on time.
- Very rarely does the train or bus arrive on time.
- You always have to be early to a station/bus stop due to the variation of arrival times deviating from the stated departure time.
- They sometimes even will leave before there scheduled time.
- Nothing is more annoying than missing a train because it came prior to the scheduled time.

Change and uncertainty

Again, the comments suggest that the respondents have a great deal of insider knowledge of system operations and failures, but are continuing to use it anyway.

- Changes are made midway along a trip.
- Stations are by-passed with little or no notice.
- Destinations are changed many times during the week and so on.
- Trains run late, are cancelled or their route is changed without any notice.
- Often cancelled at short/no notice meaning a long wait for the next scheduled service.
- Train drivers rarely tell you within the first 5 mins why the train has ground to a halt.
- Lack of live information as to the location of the train creates uncertainty regarding arrival time.

4.2.3 Theme 3 - Environmental benefit

Over one tenth (11.8%) of respondents strongly disagreed with statement 29 ('Public transport is detrimental to the environment'). Qualitative feedback suggests twoexplanations for prioritising that statement, including one that emphasizes multiple (mass) occupancy vehicles and one that distinguishes the relative environmental benefit of electric engines.

Mass transit means fewer drivers

Comments regarding environmental benefits seem to reflect an ideological stance more than a personal interest, which suggests that the respondents would like to see other people choose public transport, and are not only interested in making their own travel mode decisions.

- Mass transit systems are obviously better.
- Brisbane should charge a congestion tax to stop single occupancy vehicles driving into the city. That would reduce congestion and travel times. It would also increase ridership.
- Public transport takes so many passengers that it must be better for the environment than everyone taking their own cars.
- Public transport is not detrimental to the environment considering the amount of single drivers it takes off the roads.

Carbon footprints

Similar to the promotion of mass transit, comments regarding the environmental benefits of public transport seem to suggest a desire to influence other peoples' behaviours. The final statement provides a caveat to the original statement of disagreement – suggesting awareness of negative environmental outcomes of poor transport infrastructure.

- The best cities in the world are ones with clean and efficient PT systems.
- Public transport allows many to travel while minimising each person's carbon footprint.
- However, one has to factor the power generation to make it work, especially trams and trains. Walk around Melbourne CBD and compare the same in Sydney and choke to death in Sydney on Bus fumes...so I suppose it depends on what it's based on, but electric systems certainly keep the city cleaner if not the pollution from the power stations.

4.2.4 Theme 4 - Personal convenience and comfort

Approximately one tenth (11.5%) of respondents strongly disagreed with statement 11 ('It is easy to find a parking space at the railway station'). Qualitative feedback suggests three explanations for prioritising that statement relating to the time that car parks reach capacity, alternative or strategic parking arrangements, and the risk of fines.

Cannot find car park if not early enough

Although they read as complaints that could be interpreted as barriers to access, comments regarding availability of parking spaces suggest a degree of institutional knowledge and acquired resilience in terms of finding ways to address the concern by adjusting personal schedules.

- There aren't enough parks. If you go after peak hour it is almost impossible to get a park.
- Finding a car spot after 8:15am is impossible
- I can almost never find parking before 9am
- I completely disagree. it always gets full at 6 in the morning
- If you get to the station really early you are likely to get a park.
- Any time after 8am (earlier at many stations) and it is impossible to find a station car park.
- They fill up way before peak hour
- If you get there after 7.30-8 you may be struggling to get a park at the station.

Alternative and strategic parking arrangements

Again, these comments reflect potential barriers to access that respondents have learned to strategically overcome in order to access stations by car.

- Often the closest parking spot is an entire block away from the station or a 10-minute walk.
- People park on grass verges at the side of the car park because all the car parks are full.
- I often have to park in suburban streets.
- My station is the end of zone 1 and early zone 2. There are many commuters from zone 2 areas parking in this station to avoid paying zone 1 + 2 transport fee.
- Many train stations areas do not have sufficient parking to cater for the masses of commuters who drive to their nearest Zone 1 station to catch the train at a reduced cost

Parking fines

These comments indicate a perception of financial risk associated with driving to railway stations. Without institutional knowledge regarding the best times to secure a parking space, the risk of fines might present a financial or psychological barrier to access.

- The council likes to cash in on unfair fines for unsignalised parking areas around train stations.
- Parking anywhere else results in fines.

A smaller, but notable proportion (7.6%) of respondents strongly disagreed with statement 20 ('The railway station is a comfortable place to relax). Reflecting similar concerns, (7.6%) of respondents

strongly agreed with statement 24 ('I don't like to spend time at railway stations'). Qualitative feedback suggests two explanations for prioritising those statements including a perception of some stations as lacking physical and/or social amenity and a perception of some stations and overcrowded and unsafe.

Boring and uncomfortable

At face value, these comments describe negative conditions of railway stations that may be more applicable to older or poorly maintained stations. However, the fact that respondents made these remarks to explain their prioritisation of the statement regarding a comfortable place to relax suggests an unmet demand.

- Seats are metal and uncomfortable. Where am I supposed to relax?
- It is not comfortable and you can't really do much.
- Nothing to do at or near the railway station (Petrie) to occupy myself - shelter doesn't shield from the cold during evenings, toilets very dirty
- Waiting for long periods of time can be boring and uncomfortable at train stations.
- Suburban stations are too boring.
- Uncomfortable, hot/cold, smelly, wet, delinquents, graffiti... NO toilets, no staff, poor lighting, bad PA systems.

Crowded and unsafe

In contrast to the statements regarding boring, uncomfortable stations, these comments suggest potential psychological barriers to rail access resulting from antisocial behaviour.

- It is very difficult to relax with lots of people coming and going and school kids all around the station.
- City stations have too much commotion to be good places to socialise.
- It is generally noisy at the central stations and the other stations are not too safe at night.
- There are often trouble makers loitering around railway stations.
- I get intimidated/unsafe staying with youths and strangers in the railway station.
- Too many bogans attempting to trick money out of you under the pretence that they need it for train travel.
- I never liked to go on railway stations because it's very crowded and it stresses me out.
- I don't feel really safe in a railway station.

4.3 Open Response Feedback

In addition to interpreting the top prioritised statements, respondents were invited to explain their current ridership and to speculate about conditions that would encourage them to increase their trip frequency. Table 4 presents the most frequently mentioned concerns and shows examples of respondents' comments. In contrast with the statement sorting exercise, responses to the open answer questions were much more focused on the technical dimension of accessibility (timing and reliability).For example, the most frequently mentioned issues explaining current ridership included the frequency of trip demand, the proximity of stations to destinations, travel times and service frequency. Several respondents also mentioned lacking a viable alternative.

Suggestions for increasing service were generally consistent with the explanations for current ridership. They mentioned improving service frequency, reliability and timing, decreasing fares, and providing faster trains and more train lines. Additionally, respondents suggested making trains more comfortable, but did not describe the same improvements for stations. Some comments suggested that increasing ridership for those using the service daily was not likely.

Table 4: Summary of feedback explaining frequency of rail transit.

Concerns (times mentioned)	Example Comments
Work/study location and timing (64)	- Work location. If CBD then all the time (to use train). - How often I need to go to university

	• My working hours (9-5, Monday to Friday)
	• How many days I have to come to work
Proximity (13)	• End station's proximity to destination
Travel time (13)	• I usually drive when going out of the city.
	• Faster and I don't need to check on timetable for the bus or train
Service frequency (13)	• Frequency of the service.
	• If outside of peak hours, I rarely travel because of the lack of frequency
Car or license availability (11)	• The fact that I don't have a car
	• Only way for me to make independent travel - do not currently hold a valid driver's licence.

Table 5: Summary of feedback suggesting conditions that would encourage more trips.

Conditions (times mentioned)	Example Comments
More frequent and longer open hours (44)	• More frequent times
	• Improved frequency and express trains
	• Takes too long to get home… service is not frequent.
	• Better timetables for trains
	• Frequency during the off-peak times
	• Later weekend services
Lower fare (30)	• Lower fares, weekend fares for holidays
	• Lower fares
Distance to station (23)	• Availability of train routes close to where I need to go.
	• If I moved closer to the station
Already enough (16)	• Nothing, I always catch it into the city
	• I am doing it 5 days a week already, so no thanks.
More reliable (13)	• Reliability is a BIG factor
	• Fewer cancellations in the early morning.
Cleaner and more comfy (13)	• Cleaner
	• More seating
	• More sitting room coming home
	• less air-con, more quiet carriages, some sort of window on the trains to get fresh air
Faster (11)	• Faster, to avoid road traffic

4.4 Latent Factors in Statement Sorts

To uncover commonfactors underlying respondents' rankings of the 36 statements, we conducted exploratory common factor analysis. Since the sum of statementrankings for each individual equals a constant (i.e., zero in this case), it was necessary to delete one or more columns associated with selected statements to obtain a non-singular matrix (Jackson &Alwin, 1980).This study first divided the whole ranking matrix into sub-matrices by grouping statements of closer topics and then applied factor analysis to each sub-matrix respectively. For each sub-matrix, a simple factor structure was sought. Statements were removed or added to a sub-matrix for re-calculations to seek a simple and interpretable factor structure.We used SPSS 18.0 to calculate factors using maximum likelihood extraction with oblique Promax rotation. The number of factors to extract from each sub-matrix of statement rankings was determined by the number of eigenvalues greater than one, which meant the number of sources of shared information.

Finally, we selected two sub-matrices of statement rankings (See table 6). The first sub-matrix included the ten statements loadedon factorsA to D. The second sub-matrix included the eight statements loaded on factors E to G.No common factor was found in the rankings of the remaining 18 statements. In total, seven factors were indentified from those two sub-matrices. Each factor was named based on its statements and overall signs of loadings.

With maximum likelihood extraction,the factor loading of a statement on a factor could be interpreted as the estimated weight this statement's rankings put on this latent factor score. For example, the four statements loaded on factor A were about the railway station's function as a public or social place.The loading of statement # 26 was negative while all the other three were positive. This meant that the score of latent factor A had a negative impact on the ranking score of statement #26 but positive impacts on the ranking scores of statements #35, #20, and #22. Since the Likert-scaled ranking score (-4 to +4) in this attitude survey meant 'most disagreed' to 'most agree', factor A was named against the meaning of statement #26 but in line with the other three statements.

To examine the impacts of the common factors on rail use frequency, factor scores were compared between respondent groups statified by their reported average weekly single-direction trips by train. The respondents were thus split into three groups, i.e., low (60 respondents with 0-3 trips/week), middle (37 respondents with 4-6 trips/week), and high (47 respondents with 7 or more trips/week).

The score of a factor is calculated as the weighted (using factor loadings) average of standardised ratings of the statements heavily loading on this factor. This kind of non-refined method to estimate factor scores was also used by other researchers (see, e.g., Black et al., 2001; Syed & Khan, 2000). As noted by DiStefano et al. (2009), non-refined factor scores are, in general, thought to be more stable across samples than refined methods when the scales used to collect the original data are untested and exploratory, with little or no evidence of reliability or validity. Figure 3 compares the average factor scores between respondent groups by rail use frequency. It can be seen that the groups of higher rail use frequencies have significantly lower average scores on the factor D, "inconvenience of access journey", which is reasonable.

Table 6: Factor structure underlying the statement ranking scores

Factor	Statement	Loading	Impact
First Sub-matrix			
A: station as a public and social place	#26: bus and railway stations are dirty and smelly.	-1.011	Strong negative
	#35: the railway station is a great place to socialize.	0.331	Positive
	#20: the railway station is a comfortable place to relax.	0.301	Positive
	#22: I can get work done at the railway station and on the train.	0.228	Positive
B: safety and security	#7: I am intimidated by youths and strangers at railway stations.	1.014	Strong positive
	#8: I feel safe travelling to and from the railway station.	-0.404	Negative
	#10: Neighbourhoods near railway stations are safest.	-0.244	Negative
C: transfer cost	#3: Coordinating transfers is difficult and annoying.	1.014	Strong positive
	#25: It is a waste of time transferring from the bus to the train	0.220	Positive
D: access journey	#15: Getting to the railway station is inconvenient.	0.992	Strong positive
Second Sub-matrix			
E: friendly and approachable service	#31: I feel welcome and comfortable on public transport.	0.642	Positive
	#33: Public transport staff and drivers are helpful and friendly.	0.630	Positive
	#14: Public transport staff and drivers are hard to understand.	-0.583	Negative
F: physically active	#32: I enjoy the energy and commotion of a busy	0.620	Positive

traveller	railway station.		
	#30: The climate here is ideal for rail travel.	0.495	Positive
	#18: There are too many stairs to climb at the railway stations.	-0.264	Negative
G: environmentalconcern	#27: I'm concerned about air pollution caused by car traffic.	0.744	Positive
	#29: Public transport is detrimental to the environment	-0.390	Negative

Figure 3: Comparison of factor scores between respondent groups stratified byuse frequency
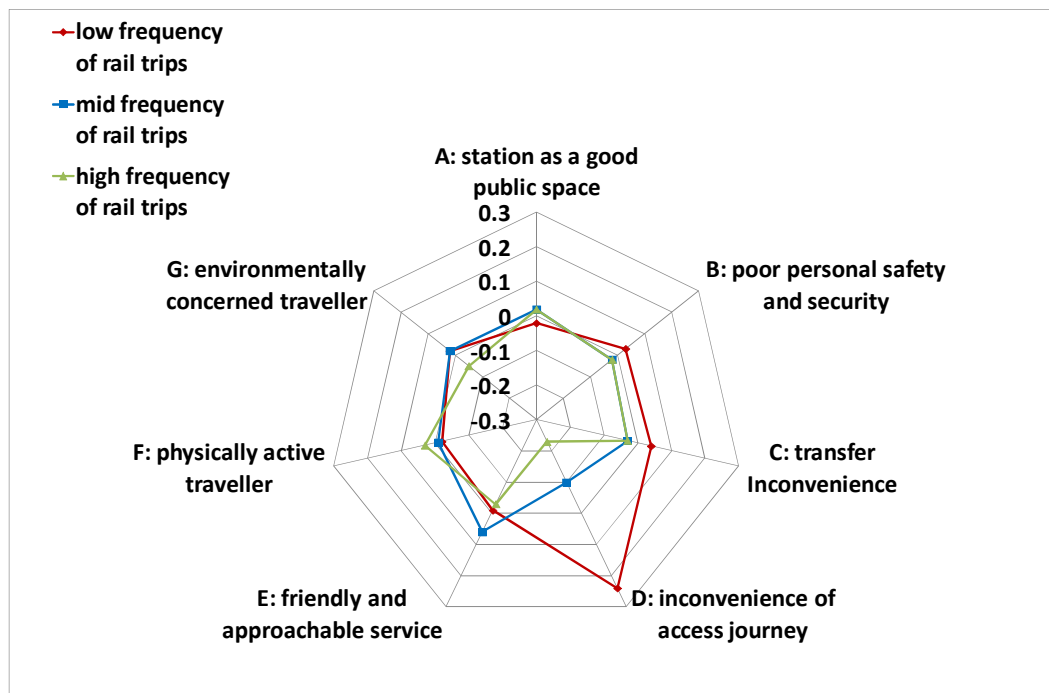
5. Discussionsand Conclusions

The purpose of this research was to develop and test a research tool for investigating subjective perspectives of rail passengers in order to make rail travel more accessible. By testing the tool under divergent conditions and relatively small samples of respondents, this study demonstrated the potential of the statement sorting exercise to identify similarities and difference among passengers. Additional factor analysis of the data from that statement sorting exercise indicated that the concept "accessibility" includes multiple dimensions that may be useful for guiding policy and operations.

Previous research regarding accessibility has conceptualized rail travel as a benefit to support social inclusion. It has tended to emphasize an opportunity dimension of travel behaviour choices. However, rail operators recognize the need to increase ridership more broadly in order to improve the economic viability of rail service, and to magnify the role that rail travel plays in making cities feel liveable. Although the underlying concern for rail travel to be "accessible" in terms of the opportunity to ride remains relevant, thenew research agenda aims to increase the number of trips made by current passengers as well as non-passengers, pointing to another significant dimension of travel behaviour choice – namely the desire or propensity to take the train.

Policy makers face a trade-off between network expansion and improving existing service. Public transport has contradictory missions ofcoverage (i.e., to serve all parts of community) and ridership (i.e., to maximise ridership with fixed budget). Most transit agencies adopt both goals but rarely reconcile them (Walker, 2008; 2012). Implicit in the coverage objectiveis asocial equity concern in both horizontal (i.e., tax payers deserve transit service as what they paid for, even if some people do not use it much) and vertical dimensions (i.e., transit costs should be smaller and benefits greater for

people who are physically, economically or socially disadvantaged). Arguments for coverage-based service refer not only to how many people need it but also to the severity of that need.

On the other hand, implicit in the ridership objective is aneconomic efficiency concern. It calls for deploying services the way private business would, with the aim of the highest possible ridership for a given service budget. An agency pursing ridership should allocate service among areas based on their ridership potentials to achieve highest productivity, which is usually measured by farebox recovery. In addition, ridership isvital to otherimportant public policy goals such as reducing road congestion, mode shit from car to public transport and resulting sustainability.A clear and consistent definition of objectives is prerequisite for policy prescription, implementation, and evaluation.

SEQ's future vision of suitable transport (Queensland Government, 2011) recognizes that a sustained shift away from unsustainable travel habits requires investment in alternatives. This study identified seven latent factors underlying passengers' perceptions of rail transit, i.e., station, safety, access, transfer, service attitude, traveller's physical activeness and environmental concern. These findingssuggest a need to re-conceptualize accessibility to intra-urban rail travel in agreement with the current policy agenda, and to target behavioural intervention to the various dimensions of accessibility influencing passengers' travel choices.Further research could build on the dimensions of accessibility identified in this study by operationalizing each factor in a dedicated questionnaire and distributing it to a representative sample of frequent and infrequent users.

Acknowledgements

References

Anable, J. (2005). 'Complacent car addicts' or 'aspiring environmentalists'? Identifying travel behaviour segments using attitude theory. Transport Policy, 12(1), 65–78.

BITRE (2007). Estimating Urban Traffic and Congestion Cost Trends for Australian Cities. Working Paper71.Bureau of Transport and Regional Economics, Australian Government.

BITRE (2009) Australian Transport Statistics Yearbook.Bureau of Infrastructure, Transport and Regional Economics, Australian Government.

Bachand-Marleau, J., Larsen, J., & El-Geneidy, A. M. (2011). Much-anticipated marriage of cycling and transit: How will it work? Transportation Research Record, 2247, 109-117.

Balcombe, R., Mackett, R., Paulley, N., Preston, J., Shires, J., Titheridge, H., Wardman, M., & White, P. (2004). The Demand for Public Transport: A Practical Guide (TRL Report 593). Wokingham, UK: TRL Limited.

Beimborn, E.A., Greenwald, M. J., & Jin, X. (2004).Transit accessibility and connectivity impacts on transit choice and captivity. Transportation Research Record, 1835, 1-10.

Beirao, G., & Cabral, J.S. (2008).Market segmentation analysis using attitudes toward transportation. Transportation Research Record, 2067, 56-64.

Ben-Akiva, M., &Lerman, S. R. (1979). Disaggregate travel and mobility choice models and measures of accessibility. In D. A. Hensher& P. R. Stopher (Eds.), Travel behaviour research: The leading edge (pp. 527-546). Oxford: Pergamon.

Black, C., Collins, A., & Snell, M. (2001).Encouraging walking: The case of journey-to-school trips in compact urban areas. Urban Studies, 38(7), 1121-1141.

Blainey, S., Hickford, A., & Preston, J. (2012). Barriers to passenger rail use: A review of the evidence. Transport Reviews, 32(6), 675-696.

Börjessen, M. (2012). Valuing perceived insecurity associated with use of and access to public transport. Transport Policy, 22(1), 1-10.

Brons, M., Givoni, M., &Rietveld, P. (2009). Access to railway stations and its potential in increasing rail use. Transportation Research, 43A, 136-149.

Burns, L. D. (1979). Transportation, temporal and spatial components of accessibility. Lexington, Toronto: Lexington Books.

Cervero, R. (2001). Walk-and-ride: Factors influencing pedestrian access to transit. Journal of Public Transportation, 3(4), 1-23.

Currie, G. (2011). Free fare incentives to shift rail demand peaks medium term impacts. Proceedings of the 90th Transportation Research Board Annual Meeting.Washington, D. C., USA.

Dalvi, M. Q., & Martin, K. M. (1976). The measurement of accessibility: Some preliminary results. Transportation, 5(1), 17-42.

DiStefano, C., Zhu, M. &Mîndrilă, D. (2009). Understanding and using factor scores: Considerations for the applied researcher. Practical Assessment, Research & Evaluation, 14(20), 1-10.

Eboli, L., &Mazzulla, G. (2010).How to capture the passengers' point of view on a transit service through rating and choice options. Transport Reviews, 30(4), 435-450.

European Committee for Standardization (2002). Transportation – Logistics and Supply of Services – Public Passenger Transport, Service Quality Definition, Targeting and Measurement (No. EN 13816: 2002 E). Brussels, Belgium.

Geurs, K. T., & van Wee, B. (2004). Accessibility evaluation of land-use and transport strategies: Review and research directions. Journal of Transport Geography, 12(1), 127-140.

Gianopoulos, G., & G. Boulougaris (1989). Definition of accessibility for railway stations and its impact on railway passenger demand. Transportation Planning and Technology. 13(2), 111-120.

Givoni, M., &Rietveld, P. (2007).The access journey to the railway station and its role in passengers' satisfaction with rail travel. Transport Policy, 14, 357-365.

Hackert, C., &Braehler, G. (2007).FlashQ (Website: www.hackert.biz/flashq). Accessed in October, 2012.

Iseki, H., & Taylor, B.D. (2010).Style versus service – An analysis of user perceptions of transit stops and stations. Journal of Public Transportation, 13(3), 39-64.

Jackson, D. J. &Alwin, D. F. (1980).The factor analysis of ipsative measures. Sociological Methods and Research, 9(2), 218-238.

Kittelson& Associates, KFH Group, Parsons Brinckerhoff, Quade& Douglass, & Hunter-Zaworski, K. (2003).Transit Capacity and Quality of Service Manual (2nd Ed.)(TRCP Report 100). Washington, D.C.: Transportation Research Board.

Kittelson&AssociAtes, AECOM, Toole Design Group, Levinson, H. S., &Schofer, J. L. (2012).Guidelines for Providing Access to Public Transportation Stations (TRCP Report 153). Washington, D.C.: Transportation Research Board.

Lam, W., &Morrall, J. (1982). Bus passenger walking distances and waiting times: A summer-winter comparison. Transportation Quarterly, 36(3), 407-421.

LEK, LLC. (2010). Meeting the Funding Challenges of Public Transport. Report prepared for Australia Tourism & Transport Forum (TTF).

Litman, T. (2008).Evaluating Accessibility for Transportation Planning.Report of Victoria Transport Policy Institute.

Litman, T. (2011).Valuing transit service quality improvements. Journal of Public Transportation, 11(2), 43-63.

MetroTrains (2013). Journey Planner (Website: metrotrains.com.au/plan). Accessed in Feb 2013.

Morris, M., Dumple, P., & Wigan, M. (1979). Accessibility indicators for transport planning, Transportation Research, 13A(1), 91-109.

Murray, A. T., Davis, R., Stimson, R., & Ferreira, L. (1998).Public transportation access. Transportation Research, 3D(5), 319-328.

Queensland Government (2011).Connecting SEQ 2031 – An Integrated Regional Transport Plan for South East Queensland.Department of Transport and Main Roads.

Syed, S. J. & Khan, A. M. (2000).Factor analysis for the study of determinants of public transit ridership. Journal of Public Transportation, 3(3), 1-17.

Texas Transportation Institute (1996). Guidelines for the Location and Design of Bus Stops (TRCP Report 19). Washington, D.C.: Transportation Research Board.

TransLink (2013).Journey Planner (Website: jp.translink.com.au). Accessed in Feb 2013.

UITP (2004).Improving Access to Public Transport. Paris: European Conference of Ministers of Transport.

Vandenbulcke, G., Steenberghen, T., & Thomas, I. (2007). Accessibility Indicators to Places and Transports: Final Report. Belgian Science Policy and SPF Mobility and Transports, Brussels.

Wardman, M., & Tyler, J. (2000). Rail network accessibility and the demand for inter-urban rail travel. Transport Reviews, 20(1), 3–24.

Wardman, M. (2004). Public transport values of time. Transport Policy, 11(4), 363-377.

Walker, J. (2008). Purpose-driven public transport: Creating a clear conversation about public transport goals. Journal of Transport Geography, 16, 436-442.

Walker, J. (2012). Human transit: How clearer thinking about public transit can enrich our communities and our lives. Washington, D. C.: Island Press.

Wibowo, S. S., &Olszewski, P. (2005).Modelling walking accessibility to public transport terminals: Case study of Singapore Mass Rapid Transit. Journal of the Eastern Asia Society for Transportation Studies, 6, 147-156.

Wu, B. M., & Hine, J. P. (2003).A PTAL approach to measuring changes in bus service accessibility. Transport Policy, 10, 307-320.

Zhao, F., Chow, L., Li, M., Gan, A., &Ubaka, I. (2003). Forecasting transit walk accessibility: A regression model alternative to the bugger method. Transportation Research Record, 1835, 34-41.

Zuniga,K. D., Bunker, J. M., & Bevrani, K. (2013). Intra-urban rail 'access': Policy implications of five revealed perspectives from a pilot Q sorting exercise. Proceedings of the 92th Transportation Research Board 92nd Annual Meeting. Washington, D.C., USA.