Prospects for shared electric velomobility: Profiling potential adopters at a multi-campus university

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Profiling potential adopters of electric bicycle sharing at a multi-campus university

Abstract

Electric velomobility (e-velomobility) encompasses human movement using electric-assisted bicycles (pedelecs, or e-bikes), and the associated practices, systems and technologies. It is emerging as an active mode in developed economies. Electric bicycle sharing (EBS) schemes can attain higher per-vehicle use time and provide more equitable access than personal ownership. University campuses are ideal testing beds for such systems as young and lower-income groups are present there. The goal of this study is to understand the segmentation of the market for a hypothetical electric bicycle sharing scheme located in a multi-campus university. A cross-sectional survey was conducted at a multi-campus university in South East Queensland, Australia. Motives, reasons, and intention of students and staff for potential future use of a potential campus-based EBS scheme were revealed. Three distinctive potential user groups with varied modal, socio-demographic, and psychological characteristics emerged in the clustering analysis, namely: "multimodal enthusiasts" (28%), "car-loving pragmatics" (46%), and "car-loving skeptics" (26%). We identify the key market segments and potential adopters' demographics (residential location, country of origin, income, and academic major). Our results indicate that respondents who are more multimodal, especially those cycling often and with shared mobility experiences, are more positive about using e-bike sharing. Largely mono-modal car users tend to be more negative towards the scheme. International students also tend to be more positive. The individual preferences and attitudes towards campus-based shared e-velomobility, as revealed in this paper, provide important insights for planners, policymakers and sharing operators seeking to launch or improve uptake of such schemes.

Keywords: micromobility, velomobility, e-bike sharing, pedelec sharing, campus travel, cluster analysis

1. Introduction

Societies with high levels of motorization in transportation are unsustainable, and contribute significant amounts of greenhouse gas emissions and local air pollution. Car dependence also causes a range of social vulnerabilities, including transport inequality from energy dependence (Leung et al., 2016) and health impacts from lack of physical activity (Bassett et al., 2008). Recently, the notion of "*three revolutions*" in transportation technologies have been widely promoted, namely: i) electrification; ii) shared mobility, and iii) automation may revolutionize current wasteful transport practices and create a more sustainable future (Fulton et al., 2017; Sperling, 2018). These revolutions are often driven by a vision of more sustainable transportation. However, skeptics question the actual effectiveness of these innovations and whether new problems will emerge when electric and/or autonomous vehicles are widely used. In fact, many of the futurist visions of the past fall short of expectations, or simply did not eventuate. Black (2001) challenged nine then popular transport visions (or myths) in the 2000s, critically questioning whether they would ever materialize. This included whether "telecommuting would reduce urban travel" or "globalization will decrease transport". In revisiting the discussion, Lane (2019, p. 2) – with hindsight – concluded five were indeed proven myths, while four still showed potential to improve sustainability in transportation. Lane questioned some optimistic assumptions under the "three revolutions" rubric, calling for research into factors influencing or discouraging people in adopting transformative technologies in combination and in more heterogenous environments (p. 9). This research paper in part answers that call, but with a focus on the electrification of bicycles, or e-velomobility. We would also argue that in addition to the purported three revolutions, a "fourth revolution" of micromobility - the trend toward adopting smaller and lighter vehicles, for example, e-scooters, e-bikes, or e-mopeds - is currently well underway (see Section 2.1 for detail).

The behavioral change needed for the modal shifts implied by the three revolutions could be hastened if supporting policy measures are in place. To design and implement these measures effectively, the individual preferences and attitudes of travelers need to be understood (Adjei and Behrens, 2012; Fürst, 2014). Contrary to popular belief, the influence of sociodemographic variables (e.g. age or gender) on sustainable consumer behavior is rather limited (Diamantopoulos et al., 2003). Attitudes and perceptions play a much more important role in fostering motivations for sustainable travel over time (Friman et al., 2019). Such factors are informed by social psychology, widely used and well-established in transport behavior research (Kwon and Silva, 2019). However, proponents of social practice approaches (Hargreaves, 2011; Reckwitz, 2002) point to limited policy successes. Critique of the attitude-behavior-choice logic cites value-action gaps (Shove, 2010; Watson, 2012) or attitude-behavior gaps (Kalafatis et al., 1999), and bemoans the lack of consideration of context, biography, and existing practices. Economists may argue pricing is paramount, but evidence have shown even lowering the price to use public transport to zero (i.e., free fares) may not produce long term effects due to rebound effects and (in)elasticity of demand (Cats et al., 2017; De Witte et al., 2008). Transport planners and operators should therefore consider attitudinal and perceptional factors when seeking to promote transition to sustainable transport. To do so, profiling (or segmenting) different potential target groups using attitude-based approaches is one recommended approach (Haustein and Hunecke, 2013). Such findings can also help develop more effective marketing with targeted and tailored messaging for each segment.

In this paper, the key focus is on how potential users consider adopting e-bikes in a shared form. Potential adopters of e-bike/pedelec sharing (EBS) are relatively understudied in comparison to conventional (non-electric) bike sharing. This is particularly true for suburban areas as opposed to urban centers, and for the specific setting of university campuses. The primary goal of this paper is to understand the segmentation of the market for a hypothetical electric bicycle sharing scheme located in a multi-campus university in South East Queensland, Australia. This goal is achieved by examining psychological factors (i.e. motives, perceptions, reasons, and intention) of students and staff with a two-step clustering approach using cross-sectional survey data.

The remainder of this paper is structured as follows. Section 2 provides background on the three revolutions, and universities as natural testbeds for the introduction of EBS. We also introduce the conceptual underpinning for the attitudinal factors. Section 3 introduces the research context and outlines the methods used. Section 4 presents the descriptive and analytical results. Section 5 discuss the implications of our findings, and puts forward suggestions to practitioners. Section 6 elaborates on the limitations of our study and pinpoints avenues for future research.

2. Background and literature

2.1. Three plus one revolutions of transport

The core notion of "three revolutions" – electrification, automation, and sharing – is still focused on cars (Fulton et al., 2017; Sperling, 2018). Put bluntly, this perpetuates the questionable implication that an average weight 75-kg human being moved around in a 1.5-ton vehicle for most of their urban travel is still desirable despite the associated energy use and parking/road space needs (even if powered by renewables) and environmental impacts (including their full life cycle). A better alternative adaptation of the three-revolution framework could also emphasize the use of smaller vehicles and integration with active transport (Fulton et al., 2017). In other words, there might be a fourth (implied) revolution of "down-sizing" vehicles, making them smaller and lighter. Tackling the weight disparity directly reduces resource, energy, and land use. It also improves traffic safety for vulnerable road users. These translate into improved environmental and equity outcomes. This way of thinking encourages new lightweight personal transport modes, collectively referred as *micromobility* (Brunner et al., 2018; Fortunati and Taipale, 2017; Sheller, 2011). Micromobility has been rapidly gaining attention, both in high-profile applications such as the proliferation of shared e-bikes and e-scooters globally (e.g. operators in Australia include *Neuron, Beam, and Lime*) (Barr, 2021) and emerging research on these transport systems (Anderson-Hall et al., 2019; Clewlow, 2019; McKenzie, 2019). To date, this concept of micromobility is still novel, with no universally accepted definition. It is generally characterized by modes using small-sized, lightweight, electrically powered vehicles, usually at lower speeds, which are especially suitable for short trips. The OECD International Transport Forum (ITF) (2020) includes fully human-powered devices like bicycles in their definition of micromobility; others specify a weight threshold, e.g. 500 kg (i.e. Dediu, 2019). Micromobility in the form of e-bikes (pedal-assisted), e-mopeds (sit-on style motor scooters), and e-scooters (stand-up style) are the most widespread, especially in shared-use operations (McKinsey & Co., 2019). Each of these micromobility vehicles come with a specific set of characteristics in regards to speed, size, weight, lifestyle, and emissions ("NUMO," 2020; *OECD/ITF*, 2020), see Figure 1. As "*form follows function*", the design of each of these prevailing vehicle designs affect their cargo carrying capacity, typical travel range, and user comfort.

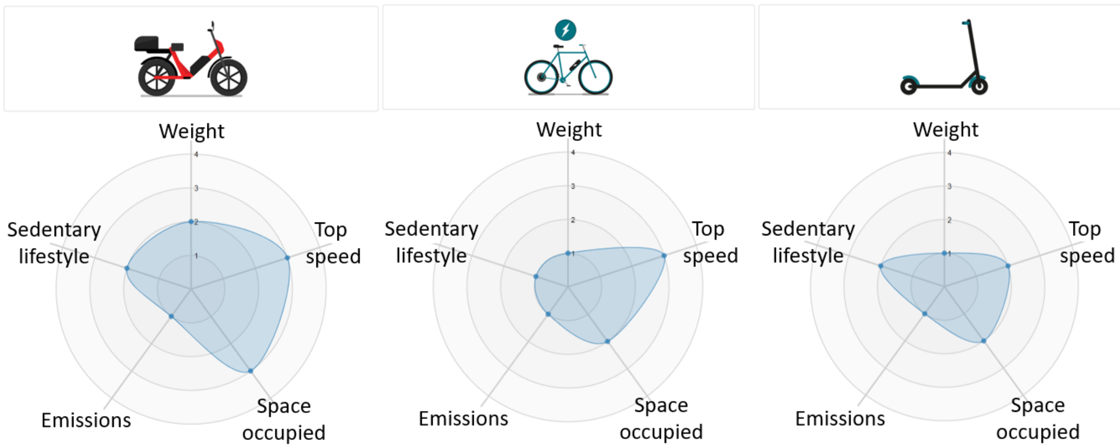

Figure 1. Visualizing vehicle attributes adapted from NUMO (2020):
e-moped, pedal-assist e-bike (pedelec), e-scooter

Unless indicated otherwise, we refer to pedal-assist electric bicycles (pedelecs) as e-bikes in this paper as to reflect Australian regulations and standards for electric bicycles[1]. E-bikes are distinct from the other powered two-wheelers (e.g. e-mopeds or e-scooters) in that they require some physical effort of pedaling to activate the motor – therefore it could be considered a form of active transport. Hence, they differ from other forms of micromobility, and may not be considered part of moto-mobilities (Pinch and Reimer, 2012), which most other micromobility devices would belong to. E-bikes also offer more space for cargo than an e-scooter, and tend to be more stable to operate with their bigger wheels. Although little research exists into the road safety of micromobility devices, some studies suggest the risk of hospitalization is higher with e-scooters than bicycles ("Austin Public Health," 2019; Bekhit et al., 2020). Due to higher speeds and vehicle mass, cars or motorcycles (including e-mopeds) have a higher risk of causing fatalities towards other road users (*OECD/ITF*, 2020). In view of these considerations, e-bikes should be considered a distinct form of micromobility. Behrendt (2018) even makes the case for referring to the mobility offered by e-bikes as *e-velomobility*[2].

[1] In Australia, there are two definitions of e-bikes allowed for public use under the *Australian Vehicle Standards*. The traditional definition refers to e-bikes as an electric motor-powered bicycle with a stated power output of more than 200W without a pedal assist system. Since 2012, a category of e-bike, modeled after the European Union CE EN15194 standard for pedelecs was introduced. CE EN15194 allows for e-bikes with a motor of 250W of maximum continuous rated power, which can only be activated by pedaling when above 6 km/h. In both cases (200W or 250W maximum power), the motor must be speed limited to 25km/h in maximum. Standards for e-moped or e-scooters are inconsistent across Australian States or Territories and are rapidly evolving.

[2] Behrendt (2018, p.66) notes that "the term velomobility (also often spelled 'vélomobility') tends to be used as a phrase to capture mobility that happens by bicycle. The term is often used in parallel, or in opposition to the term automobility". The "electric" versions of these terms are still emerging. It is acknowledged that the automobile means "self-moving" as a combined word from Greek αὐτός (autós, "self") + French mobile ("moving"). Automobile (or in short, auto) is a commonly used phase for cars or motor vehicle in the USA. The term "automobile" should encompass all energy sources, and should not require the prefix "electric" or "e-" by itself. But for now, the prefix "electric" or "e-" in short are useful as electric powered mobility are novel. We use the term e-

Pedelecs have seen rapid increase in numbers but are more concentrated in developed countries due to higher costs of ownership and operations (Behrendt, 2018). Non-pedelec e-bikes not requiring physical effort to operate have seen explosive growth in China, partly as a result of regulations aiming to restrict petrol-powered motorbikes (Fishman and Cherry, 2016; Weinert et al., 2007). Compared to "full-sized" automobiles, e-bikes are significantly more energy efficient due to their light weight – they produce significantly less emissions (both greenhouse gas and air pollutants), and with less noise. E-bikes (in particular pedelecs) also help overcome traditional barriers to cycling, such as hilly topography, warm weather and may extend travel distances, supporting broader sustainability and health goals (Jones et al., 2016). With the exceptions of urbanized areas in Netherlands, Denmark, or Northern Germany, the uptake of velomobility (using traditional bicycles) is generally higher in certain sociodemographic groups, including age (young), gender (male), place of residence (favorable flat terrain or denser urban forms), and income (more affluent households) (Jahanshahi et al., 2020). E-velomobility may help to expand cycling uptake by alleviating some of the aforementioned social or physical barriers to cycle. It may, however, create new disparities as e-bikes are more expensive, posing a cost barrier to adoption by lower-income groups (Jones et al., 2016).

2.2. The rise of E-Bike Sharing (EBS)

In recent years, e-bike use has skyrocketed and is gaining in popularity - it is the most rapidly growing product segment in bicycle sales (*Deloitte*, 2019). E-bikes are also entering into sharing services. A map initiated by Paul DeMaio in 2007 and curated by Russell Meddin contains almost 3,000 bikeshare systems worldwide (https://bikesharingworldmap.com/), including those planned, operational, and discontinued (Figure 2). Over 400 (around 13%) of these also operate at least some e-bikes (or pedelecs). The first documented EBS *cycleUshare* was launched on the campus of the University of Tennessee, Knoxville, US (Langford et al., 2013). Now EBS systems proliferate across continents, varied by system scale - the *Velocity* system in Aachen (Germany) is a pure EBS system with 100 pedelecs in 15 stations. Whereas the municipal bicycle system in Ankang, Shaanxi (China) offers a mixture of 2,200 conventional bikes and with 500 pedelecs for share in 90 stations. As part of the micromobility "revolution", global sharing operators like *Jump* (now operating as *Lime*) have placed dockless pedelecs in numerous US and EU cities alongside with other e-micromobility offerings. Up to 120 EBS systems globally are run by these multinational firms.

velomobility also to make it stand out from conventional, human powered velomobility. Velomobility (electric or not) is not a common word outside academic use. Electric bicycles (or e-bikes) are more common, and hence used in the rest of this paper.

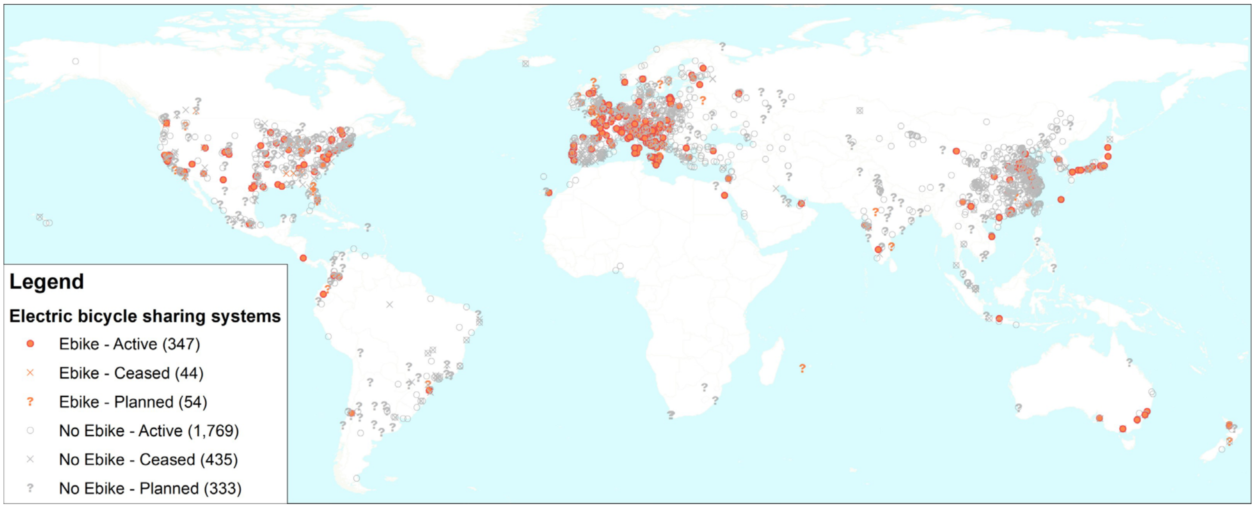

Figure 2. Global locations of bike sharing systems, as of July 2020
(Data source: https://bikesharingworldmap.com/ "The Meddin Bike-Sharing World Map")

Feasibility studies for EBS have also been conducted (e.g. Fishman et al., 2018; Olson et al., 2015; Portland State University, 2017). In Australia, while the promotion of pedelecs has certainly been on the policy agenda (e.g. Washington et al., 2019), to date pedelec sharing remains mostly on the sidelines (Fishman et al., 2018). Other nations have had more success. In Spain, the *BiciMAD* EBS was introduced in the inner city of Madrid in 2014. The over 2,000 e-bikes in 165 stations is a large operation and has been the subject of a series of studies (Munkácsy and Monzón, 2018, 2017a, 2017b).

2.3. Determinants of adoption behavior

Various psychological constructs have been theorized to influence decisions, mode choices, and behavioral change in personal transportation (Adjei and Behrens, 2012). One factor in this paper is a respondent's intention to use EBS in the future. It can predict actual behavior, as it bridges the gap between goal setting and goal striving (Bagozzi and Dholakia, 1999). Intention is one of the most commonly used psychological constructs in modeling behavior and at the core of reasoned action approaches (Fishbein and Ajzen, 2011). Prominent in the Theory of Planned Behavior (TPB) (Ajzen, 1991), intention is generally measured using question items such as "I will use EBS in the future" or "I intend to use…". In TPB, behavioral *intention* (INT) and in turn actual behavior are assumed to be motivated by the following factors (Ajzen, 2002):

- *Attitude* (ATT) toward the behavior under investigation, e.g. "I think using EBS is a good idea" (Ajzen and Fishbein, 2005);
- *Subjective norms* (SN) that reflect social pressure from significant others, e.g. "My family or friends would think using EBS is a good thing" (Amjad and Wood, 2009); and by
- *Perceived behavioral control* (PBC) that represents a perceived ease or difficulty of use, e.g. "I believe EBS would be easy to use for me" (Ajzen, 1991; Venkatesh and Davis, 2000).

In addition, past research has found other factors relevant in innovation diffusion, especially in the personal transportation context:

- *Perceived compatibility* (COM) of a (shared) transport option with one's values, needs and lifestyle, e.g. "Using EBS is consistent with the way I live my life" (Author, 2020; Moore & Benbasat, 1991); and
- *Reasons for* (RF) and *against* (RA) have been theorized and empirically found to be related to behavioral intentions beyond the effect of the aforementioned factors (Westaby, 2005a); e.g. "I would like to use EBS, because it helps improve the environment" or "I would not like to use EBS, because I worry it is not safe to ride an e-bike in traffic".

Rather than basing our investigation on motive-determined intentions alone, in this paper, seven constructs, INT, ATT, SN, PBC, COM, RF and RA, form the input for the segmentation analysis. This is hoped to provide more "texture" to the analysis results than only using behavioral intentions. The first five constructs are recognizable as Attitude, Behavioral and Choice (ABC) factors commonly found in psychological research of transport (Ajzen and Schmidt, 2020; Bamberg, 2013; Bamberg et al., 2003). Theories of behavioral change often include such factors with a focus on deliberation and elaboration. The chance for change is assumed to be higher and the effect more lasting the more the behavior under investigation is being reflected upon. More recently, a social practice theory (SPT) or approach is also being proposed as an alternative way to look at (un)sustainable behavior (Reckwitz, 2002; Shove, 2010; Schelly, 2018). It posits the importance of critically reflecting on and acknowledging the drivers of behaviors. Policy interventions are then to foster change by initiating processes of critical reflection on actions and context among a population of interest. Re-crafting, substituting, or changing the interlock of prevailing practice requires that its composing elements (materials – objects, tools, infrastructure; competence – knowledge/skills; meanings – conventions, expectations, socially shared meanings) are addressed (Shove et al., 2012). While some view the social psychology and social practice approaches as oppositional, others called for a reconciliation of both approaches (Kurz et al., 2015). Indeed, the advantage of models of behavior should not easily be discounted, as they are intuitive, explicit, and evident compared to the more obscure and less discernible impacts of society and technology. Policy seeking to foster behavior change likely needs to tackle both the individual and its societal context. Alongside the psychological factors and social practice, some theories of behavior (change), like diffusion of innovation (Rogers, 2003), focus on the effect of introducing technology and emphasize its role as change agent. These can be bicycles, cars, and in our case – electric assist of propulsion in bicycles.

The context-specific reasons for and against EBS use are a different case. They represent underlying factors determining behavior (Greve, 2001; Ryan and Connell, 1989), motivate behavior (Westaby and Fishbein, 1996), and are used by people to justify their actions or pursuing a particular goal (Galotti, 1989; Bagozzi et al., 2003; Westaby, 2005b). In this sense, reasons serve as causal explanation for people's action, and help individuals make sense of the world (Westaby, 2005a). It can be argued that changing behavior would only succeed if the reasons underlying that behavior are addressed (Katz, 1960; Snyder, 1992). As such, these context-specific reasons (why or why not people adopt a certain practice) may reflect a part of what Shove et al. (2012) offer as "meaning" in their tripartite model. Munkácsy and Monzón (2018) called on research to investigate why people choose EBS. To the best of our knowledge, no previous study has simultaneously explored reasons for and against EBS use, or included them into a user profiling exercise.

2.4. Research on EBS adopters

Using the Madrid EBS system, *BiciMAD*, as an example, Munkácsy and Monzón (2017a) found a moderate association between previous intention and actual bike-sharing use. Further, the potential users and non-users of *BiciMAD* were divided into three clusters according to their socioeconomic status, transport habits, and their knowledge of bike-sharing. The group with the more positive attitude and greater willingness to use *BiciMAD* had not ridden a bicycle in the past month or longer (Munkácsy and Monzón, 2017b). Another study (Burghard and Dütschke, 2019) from Germany examined individuals who were already using electric carsharing or pedelec sharing systems. They found the shared e-bikes in their sample to be particularly useful for older people, who sometimes live in families and are relatively monomodal in daily life. In three Polish cities a stated preference survey suggested females and seniors expressed stronger intentions to use electric bicycles (Kaplan et al., 2018); in addition, their intentions to cycle in the future depend on their travel routines: active travelers show a higher likelihood of intending to cycle than motorized travelers. Campbell et al. (2016) investigated factors influencing the choice of shared e-bikes in a stated preference study of Beijing residents. They concluded EBS would compete with public transport but also attracts car drivers. Bieliński and Ważna (2020) studied the characteristics of travel behavior among users of EBS and e-scooter sharing (ESS) in Gdansk, Poland. They found that EBS is typically used for first and last mile trips, and ESS more often for leisure. Lack of availability, reliability concerns, and no need for renting were identified as top factors discouraging EBS use. Thus far, no study has investigated potential EBS adopters or market segmentation in Australia, where the majority of travelers are car dependent and commuting distances tend to be far due to urban sprawl (Kenworthy, 2017; Dowling and Maalsen, 2020; Mattioli et al., 2020).

2.5. Universities as natural markets and testbeds of e-velomobility

Universities are large traffic generators and their campuses are often a testbed for micromobility developments; the once formidable dockless bike-sharing service *Ofo* was born at Peking University. Davison et al. (2015) surveyed students across 17 universities in Ireland and the UK, focusing on a particular aspect of travel behavior (travel to and from universities). They found males to be more inclined to engage in active transport, and also identified various differences across universities in terms of mode choices for private car, public transport, and car sharing. Students tend to have more flexible everyday habits than the working population (Whalen et al., 2013), and they have a tendency to be more multimodal (Limanond et al., 2011). University students are often willing to switch to active forms of transport – such as walking, cycling and public transport (Shannon et al., 2006). However, vehicle ownership strongly influences the mode choice of students (Limanond et al., 2011). Understanding travel behavior in and around university campuses can help in designing sustainable and efficient transportation strategies, for example, improving traffic flows and providing more incentives to use alternative modes (Khattak et al., 2011). Encouraging active transport can potentially reduce parking demand and also the university's environmental footprint. It is hoped more sustainable mobility habits and transport choices made at university will carry on later in their life. As such, university campuses are useful locations to employ natural experiments for promoting e-velomobility. No previous study has used an Australian university campus context to investigate uptake intentions.

3. Methodology

3.1. Context of Study Area

3.1.1. Nathan and Mt Gravatt Campuses in Brisbane

Our research takes places at a multi-campus university in the South East Queensland (SEQ) region of Australia. The region is largely car dependent but pockets of higher mode shares for public and active transport can be found at urban centers and key transport hubs, including universities. The study area chosen are the three largest campuses of Griffith University - Gold Coast, Nathan and Mt Gravatt campuses. Since the Nathan and Mt Gravatt campuses are close to each other, they were combined as one for the purposes of this paper. Figure 3 shows a context map of the campuses examined.

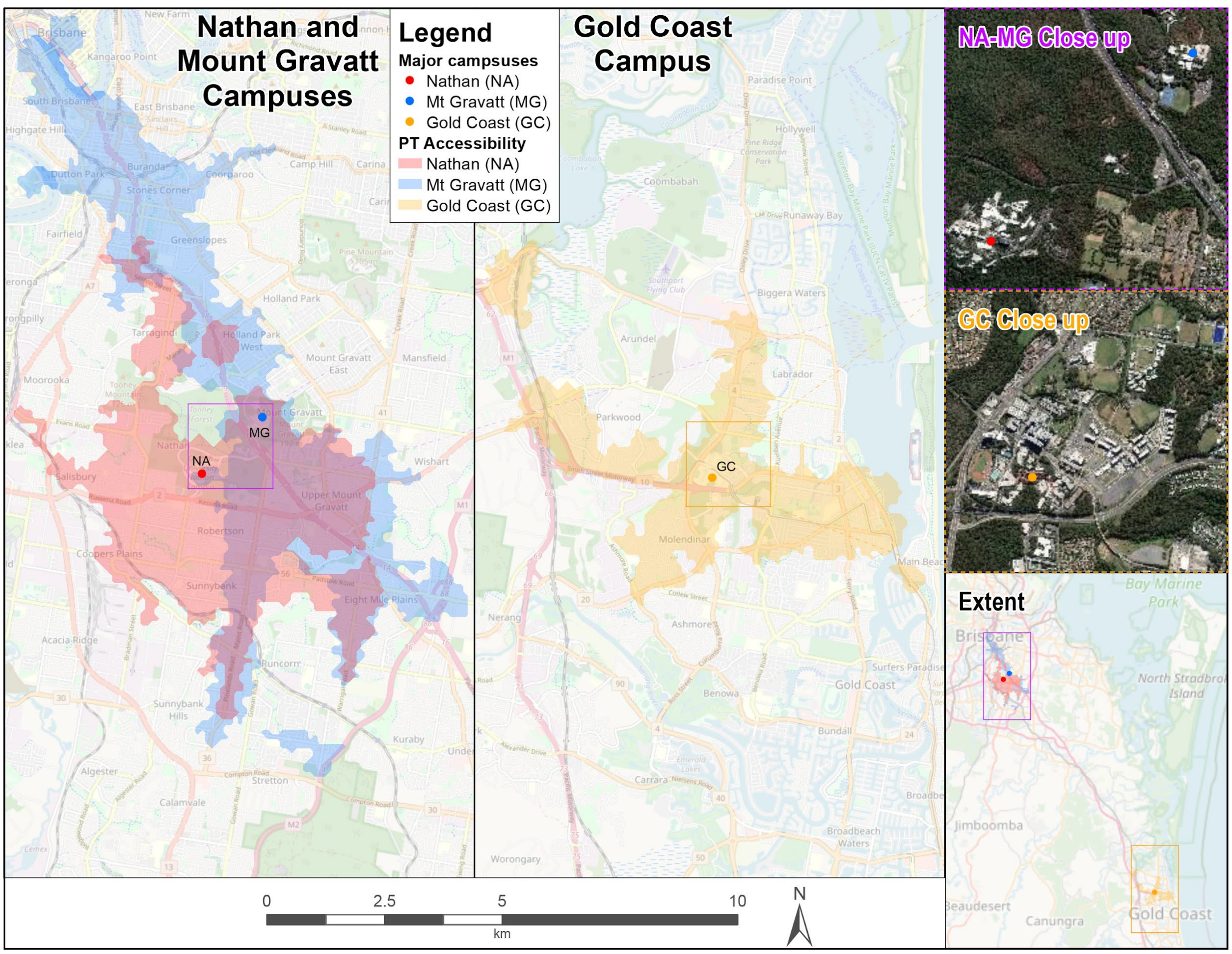

Figure 3. Contextual map of NA/MG and GC campuses showing the isochrones of the area accessible by public transport (PT) to the respective campuses within 30 minutes at 8AM weekdays (Map data source: OpenStreetMap, TravelTime platform and ESRI)

Nathan (NA) is the foundation campus of Griffith University, founded in 1971 and at the time of writing had approximately 13,000 enrolled students. A former teacher's college was added into Griffith University in 1990, forming the smaller Mount Gravatt campus (MG), with about 4,000 student enrollments. Both NA and MG campuses are located 12 km from the city center of Brisbane in a suburban location. While both campuses are only 2.5 km apart in road distance, and are connected by a network of paths, the hilly terrain and the barrier imposed by the Pacific Highway makes the campuses less accessible to each other. Walking would take half an hour, cycling would take 10 minutes but with some a 40 to 50m elevation difference. As a result, most staff or students take a free university-run intercampus bus to travel between the campuses, and NA Campus students often use this to access the Griffith University Busway Station located at the foot of the MG campus. While the MG campus is directly served by high frequency services running along the South Eastern Busway, NA is served by several more circuitous and less frequent suburban bus routes. As shown in Figure 3, despite less students being enrolled, the 30 min public transport isochrone for MG extends north and south further than for NA, and covers the city center of Brisbane.

The V1 veloway – a high quality fully segregated off-road bike path – connects to both campuses from the Brisbane central business district, and is being progressively upgraded. But cycling uptake remains modest. Many students commute by car despite better than average public bus services onto both campuses because a large number of car parks are available, and most of the catchment area is low density, car-based suburbia.

3.1.2. Gold Coast campus

Gold Coast (GC) campus is the largest campus of Griffith University. Established in 1987, it now has approximately 20,000 student enrolments. The campus is situated in the suburb of Parkwood, about 11km from the major urban center (Surfers Paradise) of the City of Gold Coast, and 50 km south of Brisbane. The campus is served by high-frequency, high-quality public transport thanks to a modern light rail service that opened in 2014; this takes students to/from the intercity heavy rail station in Helensvale to the north, and to/from the urban centers of Southport, Surfers Paradise and Broadbeach to the south. While secure parking and end-of-trip facilities with showers/lockers are available at many buildings in all Griffith campuses, there are more bike racks at the GC campus and some of them are maintained and publicly owned by the City of Gold Coast.

3.3. Data collection

As part of a larger research project, students and staff at the three campuses were surveyed to explore their intentions toward a potential EBS system. Data was collected using a combination of paper and online surveys from August to September 2019 following ethical approvals (GU ref. HREC2019/531, 2019/587). The research was designed to first explore reasons for and against using EBS in a qualitative way (Survey 1), and then, integrate these reasons in a quantitative investigation of individual attitudes, reasoning, and behavior (Survey 2). Survey 2 also included a qualitative component in the form of word associations, which provide in-depth preceptive responses and thereby add color to the quantitative findings.

While the psychological data captured how people reflect on their mobility behavior within the established framework of behavioral theory. The qualitative components allowed a less constrained reflection by participants of context, emotions, and reasons for current transport choices. Social practice in transport is also reflected in local mobility cultures, which among others can be car use, transit, or multimodality oriented (Bamberg et al., 2020; Schuppan et al., 2014; Wulfhorst et al., 2013). Self-reported modal behavior served to address this perspective.

3.3.1. Survey 1: Reason elicitation

The first survey was a pilot study (N=116) to establish preliminary understanding of EBS in Griffith University campuses. The findings of the first survey informed the instruments for the more detailed second survey. Context-specific reasons for (RF) and reasons against (RA) were elicited using a questionnaire survey with open-ended questions, alongside other socio-demographic questions.

3.3.2. Survey 2: Propensity for using EBS

Respondents were recruited by posters and email groups. To increase participation, a lucky draw for several AUD$50 cash coupons was offered as an incentive-to-respond. A total of 389 questionnaires were collected, of which 368 (94.6%) were valid after excluding incomplete and unreliable responses. Unreliability was determined based on several factors, including overall response time in online survey, suspicious patterns (e.g. straight-lining, zig-zagging, Christmas-treeing), and logical inconsistencies (e.g. frequent car use, but no driver's license). Such factors can indicate inattention or other participant misbehavior throughout the entire survey. At least two such factors needed to be present for a respondent to be flagged. The survey included questions encompassing personal demographics, e-bike preference. The sample contains 300 students and 68 staff of the NA/MG (treated as one campus) and GC campuses, including 126 students at NA/MG and 174 at GC; and 40 staff at NA/MG and 28 at GC.

At the beginning of the survey, an open-ended inquiry, "Please name three reasons why you would (not) want to use EBS", asked respondents to state a word or phrase that comes to mind in relation to a proposed EBS system. This is known as a word association (WA) test, a projective technique resulting in responses highly relevant for consumers and their decisions in relation to product or service purchases (Clifton & Handy, 2003). An important advantage of the WA approach is the minimization of social desirability bias.

Behavioral variables are measured on a 7-point Likert scale from strongly disagree (1) to strongly agree (7). Incorporating multiple sampling methods (paper, online) helped mitigate common method bias. The paper questionnaires were a convenience sample (N=91) consisting almost exclusively of science and engineering majors. They were compared against a subsample of similar students (N=66), who had participated using the online survey. None of the latent variable scores used in the cluster analysis displayed significant differences in their mean, and the same resulted when comparing students versus staff. A full collinearity check on the latent variables using the full sample did not indicate the presence of common method bias. Therefore, clustering conducted using the full sample (N=368) was deemed appropriate.

3.3. Data analysis

3.3.1. Survey 1: Reason elicitation

Survey 1 provided qualitative data regarding the reasons for (RF) and against (RA) using EBS. Context-specific RF and RA were elicited by qualitatively analyzing responses to open-ended questions (Mayring, 2014). One researcher first coded the responses. The coding scheme was then reviewed and validated by another researcher who is an experienced social scientist familiar with the target population. Based on identified reason categories, question items were developed and integrated into Survey 2 along with items for the latent factors that draw from established behavioral theory. In addition, respondents reported the demographics and characteristics of their transport mode use.

3.3.2. Survey 2: Latent variable evaluation

The first step in analyzing data of Survey 2 is a confirmatory factor analysis to establish the validity and reliability of the theorized latent variables (INT, ATT, SN, PBC, COM) and the reason constructs (RF, RA). In confirmatory factor analysis aiming to validate constructs, loadings above 0.7 are desirable, while in exploratory settings, like the present study's RF/RA, loadings as low as 0.4 are acceptable (Brown, 2015). Cronbach's alpha and composite reliability should be above 0.7 (ibid). The evaluation results are provided in the Appendix A1. The correlations between the latent variables are presented in Appendix A4. This step helped establish the validity and reliability of all constructs.

3.3.3. Survey 2: Cluster analysis

Cluster analysis was carried out using the latent variable scores of the seven behavioral factors as input (INT, ATT, SN, PBC, COM, RF, and RA). This reduced dimensions of the large number of question items. It also allowed us to identify what social practices of travel and socioeconomic background may affect the intention to use EBS. Seven factors are deemed an acceptable number given our sample size. Clusters were derived in a 2-step procedure (Everitt et al., 2011; Fürst, 2014). First, several hierarchical methods with squared Euclidian distance as a dissimilarity measure were employed using as linkage methods: single, average, Ward's, complete, weighted-average, median, and centroid. The appropriate number of clusters was determined as three (3) by examining Calinski and Harabasz pseudo-F (Caliński and Harabasz, 1974) and Duda-Hart Je (Duda et al., 2012) indices, and by inspecting the dendrogram. Among the different linkage methods, Ward's linkage yielded the most distinct solution with relatively balanced cluster sizes. Second, partitioning methods (k-means/medians) with a squared Euclidian distance as a dissimilarity measure were used for optimization starting from the cluster centers of the first step solution. The resulting cluster solutions from both steps were compared along all behavioral, demographic and transport mode variables (see also Section 4, Table 2). The quality of the solution was highlighted by the fact that not only the cluster means for the behavioral variables used as input were different with statistical significance, but also many of the control variables. The best cluster solution chosen and presented here has the highest number of statistically significant differences. It was obtained using Ward's linkage followed by k-medians partitioning. Subsequently, the hit ratio from discriminant analysis was used to validate the cluster solution. STATA 15 was used for conducting statistical analyses. Map visualizations were generated using ArcGIS.

3.3.4. Survey 2: Association with cluster membership

To assess several associations of demographic variables with cluster membership, we used an ordered logit model with cluster membership as the dependent variable. The previously obtained cluster assignment can be considered ordered regarding to positive perceptions about the potential EBS system or the intention to use EBS. All factors were included as binary variables. Brant test is used to confirm the parallel regression assumption is not violated for any variable (Brant, 1990; Long and Freese, 2006).

4. Results

4.1. Survey 1: Reasons for/against using EBS

Qualitative coding of Survey 1 responses and categorization yielded a range of reasons for and against using EBS. The most frequent ones are shown in Table 1. RF is more focused on the largest categories. Well-being involves aspects like health, fun, and positive emotions. This is followed by environmental friendliness and saving of time, money and effort in the use of EBS. RA is more diverse and includes aspects referring to increased effort, different perceived risks, and uncertainty when using EBS. These categories were used to design questionnaire statements of reasons for and against for Survey 2.

Table 1. Top five categories of reasons for and against using EBS

Reasons for (RF)	Freq.	Reasons against (RA)	Freq.
Well-being (health, fun, positive emotions)	102	Too much effort	44
Environmental friendliness	56	Risk (safety, hygiene, health)	40
Save time	42	Uncertainty	38
Ease (less effort)	41	No need	32
Save money	40	Aversion to sharing	25

The RF show some overlap with Langford et al. (2013), who reported "speed", "comfort", "convenience", and "less work required" as the main reasons for choosing a shared e-bike among users of the first North American EBS at the University of Tennessee, Knoxville. Fishman (2016) reported barriers using CityCycle, the former conventional bikeshare system in Brisbane (replaced by dockless e-bikes in July 2021). These also have some thematic overlap: "driving is more convenient", "station not close enough", "lack of riding safety", "don't carry helmet". In a feasibility study on potential e-bike use among employees at the Brisbane offices of the Department of Transport and Main Roads, Washington et al. (2019) reported "concerns about riding in traffic" as the most frequently cited barrier followed by "insufficient cycling infrastructure". Some RA correspond to factors identified by Bieliński & Ważna (2020) as discouraging EBS (e.g. "availability concerns", "no need", "hygiene"), but differing context and mobility practice are apparent (e.g. "bikes break down too often", "can't ride with children").

4.2. Survey 2: Propensity for using EBS

4.2.1. Descriptive results

The responding students were enrolled in various academic majors: science (36%), engineering (15%), management (16%), and humanities (33%). Three quarters of the students were 25 years old or younger (mean 23.4). The responding staff's average age was 38.7. Female students made up 53% of the sample, while only 35% of staff were male. 83% of students (97% of staff) had a driving license and 72% (89%) owned a motor vehicle. Table 2 gives an overview of descriptive data on latent variables, demographics, and mode use/habits. Respondents stated a postcode for their place of residence, allowing identification of students living on or near campus[3] (NA/MG: 25%, GC: 49%). Figure 4 shows the geographic distribution of respondents by postcode.

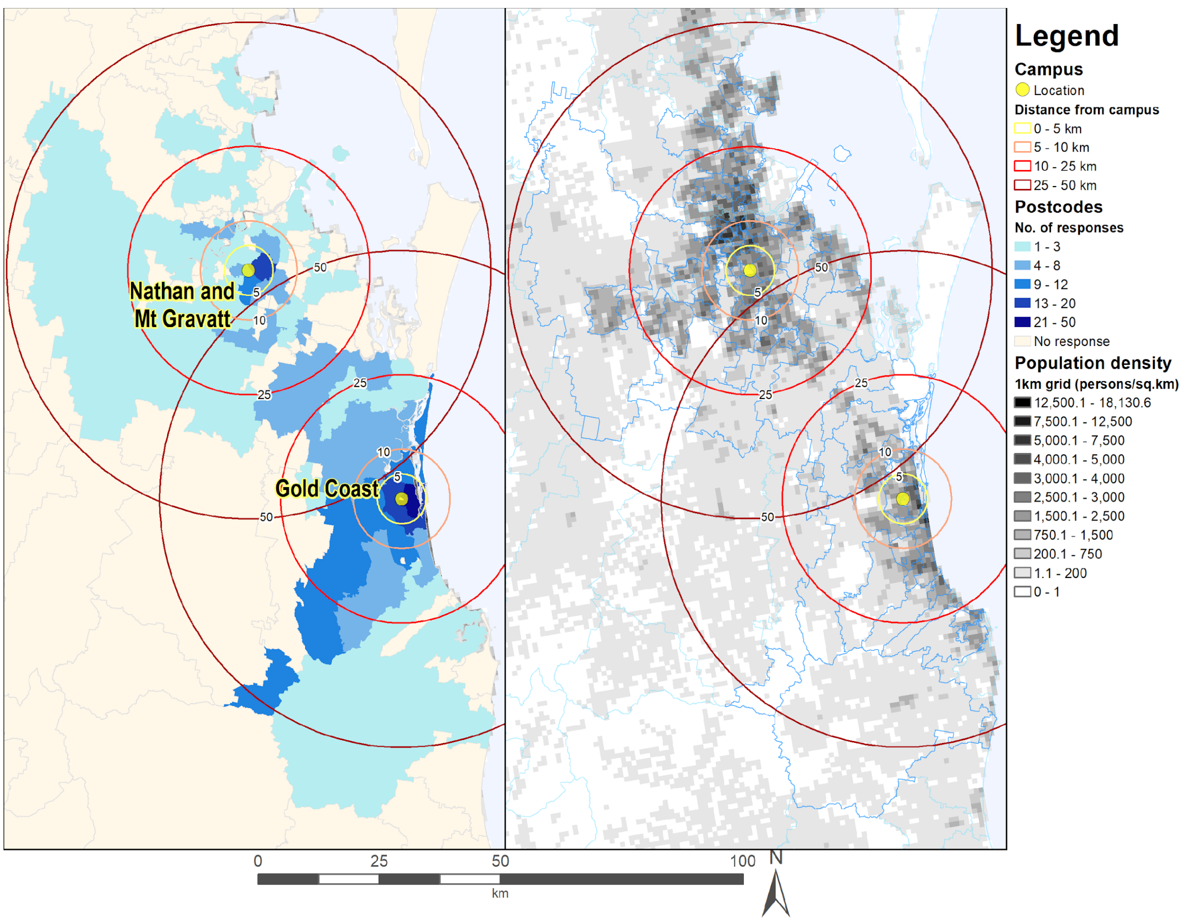

Figure 4. Respondents by postcode (N=368), Map data source: Australian Bureau of Statistics

Overall, students and staff at both campuses are receptive to the idea of campus-based EBS. Only 26 (7%) stated they would not be willing to try EBS in the future, while 245 (67%) said they will use it in the future if it becomes available. However, there are differences due to the

[3] Postcodes considered near or at campus for Nathan/Mt.Gravatt: Nathan (4111), Sunnybank (4109, Garden City (4122), Salisbury (4107), Taragindi (4121); and for Gold Coast: Southport (4215), Parkwood (4214), Surfers Paradise (4217)

geographical location of residence, citizenship, and income. Respondents who stated Australian citizenship (254 or 69%) had a significantly lower intention to use EBS in the future (5.1 vs. 5.7). They were less likely to live on or near the campus than non-Australian citizens (31% vs. 49%). Among staff members, a higher income was associated with a less positive attitude toward EBS and also a lower intention to use it.

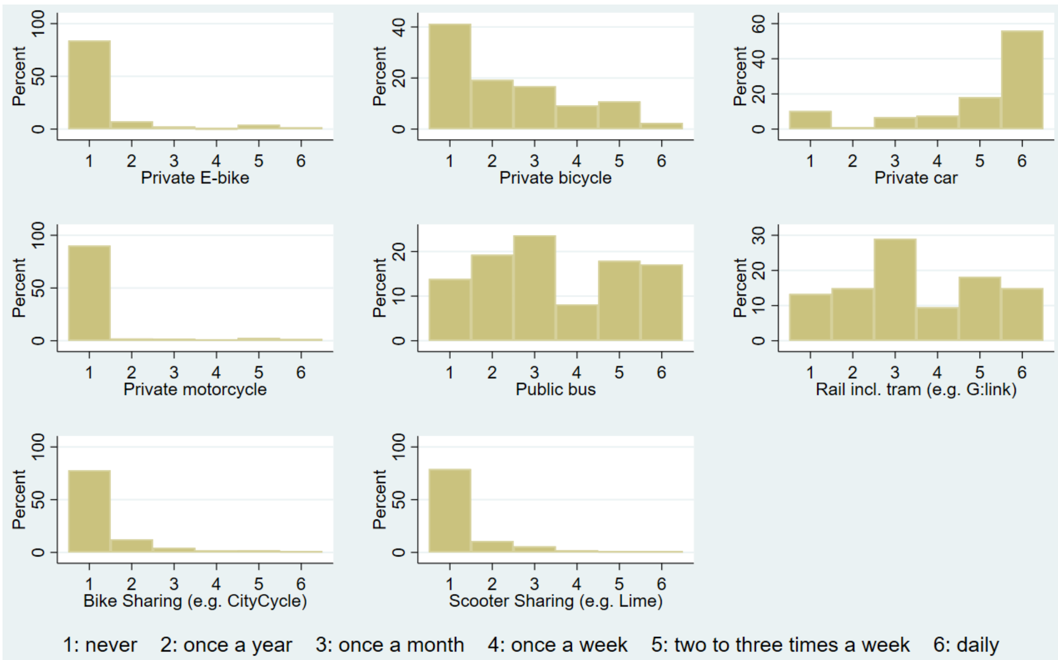

Figure 5. Past mode use in overall sample (N=368)

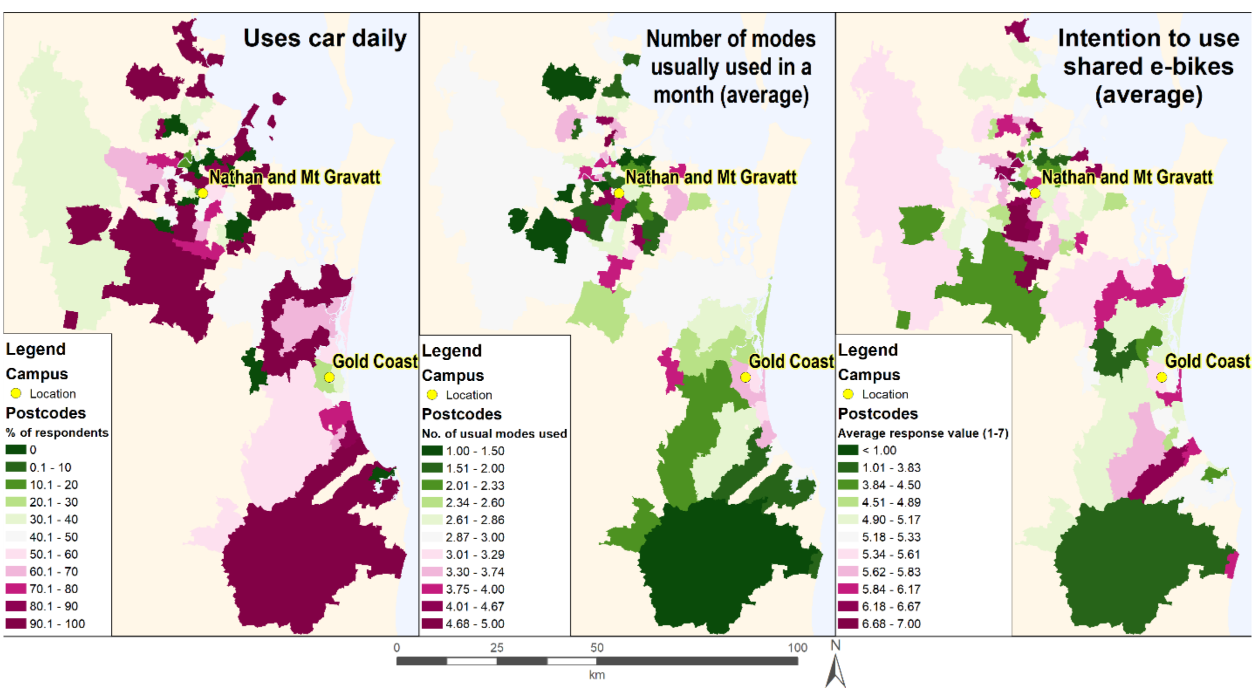

Figure 6. Car use, multimodality, and EBS usage intention by postcodes (N=368)
Intention – latent variable score with equal weights (Map data source: Author's survey)

Past mode usage (Figure 5) suggests the most common travel mode is by car. Moderate use of public transport and a lack of experience with shared mobility and e-bikes were also indicated. Recreational use is the most cited purpose for those who cycle often. In Figure 6, the geographic distributions of three selected survey outcomes are visualized. While daily car use is generally very common, in some areas closer to campuses or well-connected by public transport, this is notably lower and is accompanied by patterns of higher multimodality. Multimodality also appears to be statistically and geographically correlated with a higher intention to use EBS in the future. Due to space limitations, a descriptive analysis of the question items and latent variable measurement is presented in the Appendix A1.

4.2.2. Word Associations

Following a similar approach to reason elicitation using qualitative content analysis, the WAs were coded, categorized and grouped into three types: neutral, positive, and negative. Analysis of 30% of the material was done independently by two researchers, who then compared and discussed their coding schemes, and a final one was agreed on. Subsequently, the rest of the responses were categorized. In total, 1,505 WAs were provided, an average of almost four per respondent. 55% of all WAs were categorized as positive, 11% as negative, and 34% as neutral. The overall top five response codes were all positive: “environmentally friendly”, “easy”, “fun”, “inexpensive”, and “convenient”. These made up a third of all responses and about two thirds in the positive category. The top five negative response codes (67% of the negative category) were “expensive”, “bad”, “unsafe”, “unorganized”, and “not clean”. The WAs convey information about the meaning of EBS to participants. These vary across the identified clusters presented in the following section. A word cloud is generated based on the coded WAs (Figure 7).

Figure 7. Coded word associations (green: positive, red: negative, grey: neutral)

Table 2. Descriptive statistics with group comparison

	Total				**Students**						**Staff**						**Cluster No.**			
	All	**Staff**	**Stud**	**Sig.**	**Female**	**Male**	**Sig.**	**NA/MG**	**GC**	**Sig.**	**Female**	**Male**	**Sig.**	**NA/MG**	**GC**	**Sig.**	**1**	**2**	**3**	**Sig.**
N	**368**	**68**	**300**		**158**	**142**		**126**	**174**		**44**	**24**		**40**	**28**		**96**	**170**	**102**	
Gold Coast campus	**55%**	41%	58%	**	54%	63%		0%	100%	***	43%	38%		0%	100%	***	47%	59%	55%	
Live on/near campus	**37%**	28%	39%		33%	45%	**	25%	49%	***	25%	33%		23%	36%		27%	35%	49%	***
Male	**45%**	35%	48%	*	0%	100%	***	42%	51%		0%	100%	***	38%	32%		45%	46%	44%	
Weekly income AUD350+	**50%**	97%	40%	***	40%	39%		37%	42%		98%	96%		95%	100%		53%	52%	45%	
Weekly income AUD1500+	**6%**	28%	1%	***	1%	1%		1%	1%		25%	33%		23%	36%		7%	7%	3%	
Age over 29	**25%**	81%	12%	***	10%	16%		17%	9%	*	82%	79%		83%	79%		27%	28%	20%	
Australian citizen	**69%**	78%	67%	*	75%	58%	***	70%	65%		77%	79%		85%	68%		79%	72%	55%	***
Student	**82%**	0%	100%	***	100%	100%		100%	100%		0%	0%		0%	0%		80%	80%	85%	
Graduated from higher education	**55%**	84%	48%	***	41%	55%	**	48%	47%		80%	92%		88%	79%		53%	54%	58%	
STEM subject	**47%**	28%	52%	***	45%	59%	**	62%	44%	***	20%	42%	*	33%	21%		57%	46%	39%	**
Driving license	**85%**	97%	83%	***	80%	86%		81%	84%		98%	96%		98%	96%		90%	84%	84%	
Owns no motor vehicle	**25%**	10%	28%	***	29%	28%		25%	31%		11%	8%		10%	11%		17%	24%	35%	***
Intention	**5.3**	5.1	5.3	*	5.3	5.4		5.3	5.4		5.0	5.3		5.2	4.9		3.9	5.3	6.5	***
Perceived Behavioral Control	**5.5**	5.4	5.6		5.5	5.7	*	5.5	5.7		5.3	5.6		5.4	5.5		4.1	5.7	6.7	***
Attitude	**5.9**	5.9	5.9		6.0	5.8		5.8	5.9		5.9	6.1		5.9	5.9		4.8	6.0	6.7	***
Subjective Norm	**5.3**	5.4	5.3		5.3	5.2		5.2	5.3		5.3	5.4		5.4	5.3		4.0	5.4	6.4	***
Perceived Compatibility	**4.7**	4.7	4.7		4.7	4.7		4.6	4.8		4.7	4.7		4.7	4.8		3.2	4.8	6.0	***
Reasons FOR (RF)	**5.2**	5.0	5.3	*	5.3	5.2		5.2	5.3		5.0	5.1		5.1	5.0		4.1	5.3	6.2	***
Reasons AGAINST (RA)	**4.5**	4.3	4.5		4.6	4.3	**	4.5	4.5		4.4	4.1		4.3	4.2		5.0	4.6	3.7	***
Never used BS	**78%**	94%	74%	***	82%	66%	***	71%	76%		91%	100%		95%	93%		91%	81%	62%	***
Used BS monthly+	**10%**	0%	12%	***	5%	19%	***	13%	11%		0%	0%		0%	0%		1%	7%	22%	***
Used car rarely	**11%**	2%	14%	***	13%	14%		10%	17%	*	2%	0%		0%	4%		5%	11%	19%	**
Used car weekly+	**82%**	94%	79%	***	80%	78%		83%	76%		95%	92%		93%	96%		89%	83%	74%	**
Used car daily	**56%**	72%	52%	***	53%	51%		54%	51%		84%	50%	***	75%	68%		64%	57%	48%	*
Used bicycle weekly+	**23%**	25%	22%		15%	30%	***	21%	23%		23%	29%		28%	21%		8%	21%	38%	***
Used Sharing monthly+	**15%**	2%	18%	***	12%	25%	***	21%	16%		0%	4%		3%	0%		4%	13%	28%	***
Never used Sharing	**70%**	93%	64%	***	71%	57%	**	59%	68%		91%	96%		93%	93%		82%	72%	54%	***
No. of different modes used	**3.9**	3.5	4.0	**	3.7	4.3	***	3.9	4.1		3.6	3.3		3.5	3.5		3.5	3.9	4.4	***
No. of different modes used weekly	**2.1**	1.8	2.2	***	2.0	2.5	***	2.1	2.3		1.7	1.9		1.7	1.8		1.7	2.0	2.6	***
No. of different modes used 2-3x/week	**1.7**	1.5	1.7		1.6	1.8	**	1.5	1.8	***	1.5	1.7		1.5	1.6		1.5	1.6	1.9	**
Used >3 different modes weekly	**10%**	2%	11%	**	5%	19%	***	10%	13%		2%	0%		3%	0%		5%	5%	21%	***
Used more than 1 mode 2-3x/week	**47%**	41%	49%		46%	52%		41%	54%	**	34%	54%		35%	50%		41%	45%	58%	**

Sig. – statistically significant difference ($p<0.01$ ***, $p<0.05$ **, $p<0.10$ *); p-values obtained by: percent (count data) - Fisher's exact test, continuous – ANOVA/two-sample t-test; Latent variable scores: unweighted average of responses using 7-point Likert scale; BS=bike-sharing, STEM=science-technology-engineering-math

4.2.3. Cluster analysis

This subsection describes the resultant groups obtained from the cluster analysis in detail. Table 2 presents the mean value of each cluster group, and a range of factors were also analyzed in terms of significance and differences. Figure 8 shows the geographic distribution of the respondents for the three clusters.

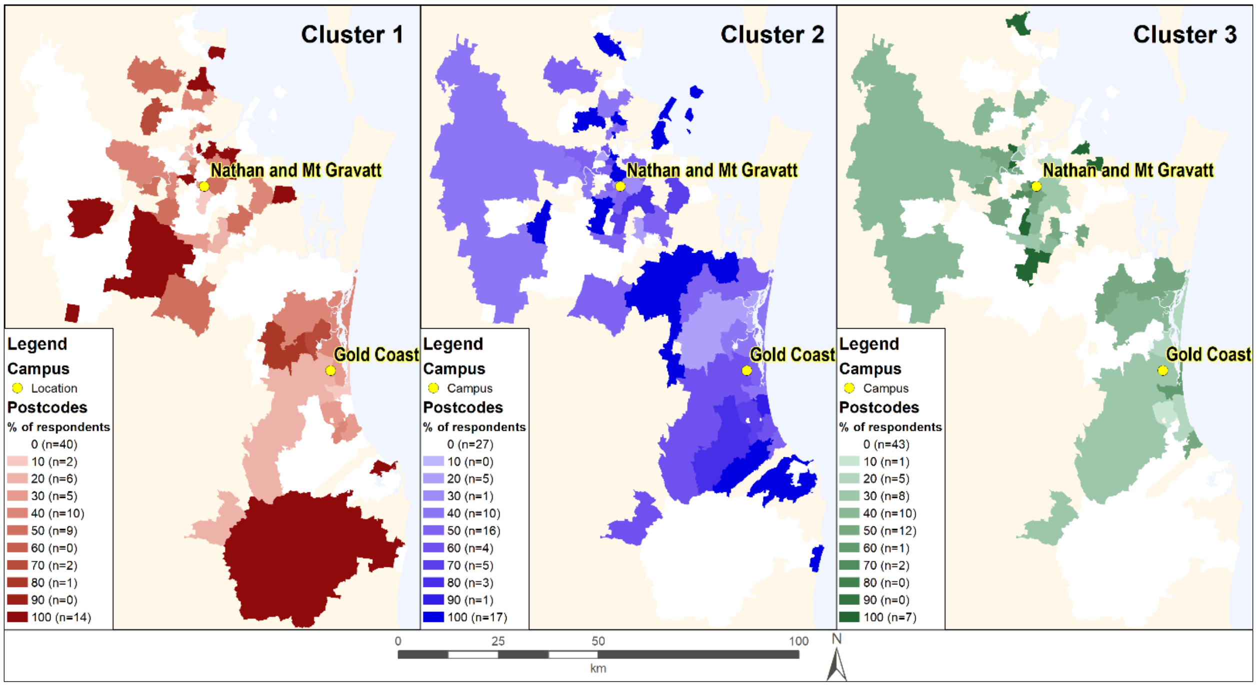

Figure 8. Cluster membership by postcodes, number of postcodes in brackets
(Map data source: Author's survey)

With respect to the seven attitudinal factors serving as the inputs for clustering, the results demonstrate a clear pattern with statistically different mean values for all latent variables in all of the three clusters identified (see Table 2). With progression from Cluster 1 to Cluster 3, a marked increase of the propensity to use EBS is observed. Members of Cluster 1 appear to be least inclined to use EBS, as they have the lowest scores for INT, ATT, SN, PBC, COM, and RF; but the highest for RA. Conversely, members of Cluster 3 have the exact opposite and the lowest for RA. Cluster 2 members are the most numerous in terms of membership size, with their scores straddling those of Clusters 1 and 3. The distinctive and statistically significant differences between the input variables highlight the quality of our resultant clustering solution. The following describes the clusters in greater detail, and a more identifiable name for each cluster is assigned based on their traits.

Cluster 1 - *Car-loving skeptics* (N=96): Respondents belonging to this cluster are not very positive about the idea of EBS. They tend to have the perception EBS is incompatible with their lifestyle (3.1), and stated strong reasons against using it (5.1). The cluster is predominantly Australian citizens (79%) with a high percentage of motor vehicle ownership (82%). Almost 70% major in a STEM subject (science, technology, engineering, mathematics). Very few have tried bike-sharing before (12%) or even cycle regularly (8%). Most of them use the car on a regular basis (88%), or even daily (60%). Only 40% use more than one mode per week. Only a minority of their WAs about EBS are positive, with notably fewer relating to “convenience”. They have more than twice as many negative WAs, especially relating to EBS “lacking safety”, being “unclean” or “uncomfortable”. Only in this cluster is EBS frequently described as “unnecessary” or as giving a “negative image”.

Cluster 2 – *Car-loving pragmatics* (N=170): Members of this cluster show generally positive attitudes and intention to use EBS (5.4), and are concerned about the environment. But the perceived compatibility of EBS with their lifestyle, values, and transport needs is significantly lower than Cluster 1 (4.8 vs. 6.0) members. In addition, they offer stronger reasons against using EBS (4.7). Most demographic factors and mode use characteristics correspond to the mean values of the overall respondents (N=368). There is much lower use of bicycles (20%), and bike-sharing (9%), and two thirds have never used shared transportation before. On average, members of this cluster use two different transport modes per week (2.1). They still associate many positive things with EBS, e.g. “convenience”, “potential money savings”, or “well-being” (like health, fun, positive emotions). But they are also concerned with EBS being “messy”, “unorganized”, or relate it to “travel uncertainties”.

Cluster 3 - *Multimodal enthusiasts* (N=102): This cluster is made up of people who state a high intention to use EBS (6.6) and score high on all other latent constructs, except reasons against (3.7). Half of this cluster’s members are non-Australians, many do not own a motor vehicle (38%), and STEM subject majors are a minority (40%). Very few appear to be captive car users, strongly agreeing it would be up to them to choose EBS (86%). Indeed, less than half use a car on a daily basis (43%), while they ride a bicycle (38%) or use public transport (79%) regularly. The range of transport modes used is highest among the three clusters (2.8), and a quarter of members even use four or more modes. Members of Cluster 3 have more positive WAs with EBS, particularly relating to “environmental friendliness” and “convenience”, and very few negative WAs. More often they associate EBS with the notion of “community”.

4.2.4. Associations with cluster membership

Detailed results for the ordered logit model are shown in the Appendix A2. Gender, driving license, vehicle ownership, graduation from higher education, and age (29+) are not associated with cluster membership in a statistically significant way. However, several other demographic factors strongly relate to cluster membership: living on/near campus (positive), Australian citizenship (negative), STEM major (negative), and higher income (negative). While the first three are immediately obvious from Table 2, the association of income (above AUD 350/week) among students only becomes apparent when accounting for its correlation with citizenship in a regression model (interaction). Despite the indication in Table 2, vehicle ownership is not associated with cluster membership in the presence of control variables in a statistically significant way.

For illustration, take the following example: a male, high-income respondent with Australian citizenship, who lives off-campus and whose major is/was in science has only a 14% probability of being a multimodal enthusiast (Cluster 3), 10% if he is university staff. While a non-Australian student, who lives on/near campus on less than 350 AUD/week, and studies in a humanities or management subject has a 68% probability membership in Cluster 3.

These associations were obtained using an ordered logit model with cluster membership as the dependent variable. Our cluster assignment can be considered ordered with respect to attitude toward and intention to use EBS. Beside the above-mentioned variables, we simultaneously account for the influences of gender, driving license, graduation from higher education, and age (29+), all of which are statistically insignificant. All factors were included as binary variables. A Brant test confirmed the parallel regression assumption is not violated for any variable (Long and Freese, 2006). Variance inflation factors were between 1 and 2, and therefore did not indicate the presence of multicollinearity. Results are shown in the Appendix A2/A3.

5. Discussion and Conclusion

The students and staff at both campuses are generally receptive to the idea of campus-based EBS. But there are differences due to the geographical location of residence, citizenship, academic major, and income. Three district social groups with varying multimodality (social practice) emerged in the clustering exercise. When examining various demographic factors in relating to cluster membership, citizenship proves to be the most prominent one. Australian citizens among the students, especially in the lower income level, appear to be much more likely to be a skeptic of shared e-velomobility (Cluster 1). It may be that the mostly East and South Asian students, who dominate the international student cohort at Griffith University, are more multimodal in their home countries. The results support the notion that international students have different lifestyles and travel attitudes/intentions compared to domestic Australian students (Shafi et al., 2020).

The distinct groups that emerged from clustering using psychological survey data also exhibit geographical differences influenced by land use factors (Figure 8). Members of Cluster 1 tend to be suburban-rural dwellers indicating a longer commute. People in Cluster 2 also tend to live in suburban areas but closer to campus. Seemingly, this raises the chance of them being positive about EBS. Cluster 3 members often live closer to or on campus, or in more urban areas with a good public transport connection. It is probable either the short distance to campus or their familiarity with shared and public transport makes them more responsive to the idea of EBS use.

As a methodological contribution, it can be noted clustering potential user groups along psychological criteria is a useful exercise to investigate potential adopters of a campus-based EBS scheme. Although clusters of respondents were obtained using only psychological variables, group differences are statistically significant in almost all measures that were used to capture mobility routines, but not for demographic indicators such as age, gender, or income. Not surprisingly, students and staff display clear differences in the demographic measures, and also their use of transport modes (Table 2). However, they differ very little in their psychological responses. Hence, it was adequate to pool both groups for the clustering procedure, where their numbers turn out to be equally distributed. For the three clusters, the following recommendations can be made to optimize uptake of a potential campus-based shared e-bike service.

- *Multimodal enthusiasts* show a high readiness to use EBS and are acutely aware of the environmental and convenience benefits of the service. As long as minimum requirements in terms of coverage, hygiene, and pricing are met, it should not be difficult to gain and retain them as users. Since half of them live on or nearby campus, shared e-pedelecs should not only be provided on-campus, but in nearby areas important to students and staff, like popular lunch locations, libraries and shopping destinations. To encourage retaining multimodal behavior, public transport hubs should be integrated in a potential location plan, e.g. the light rail stations at the Gold Coast, or the busway station near Nathan campus. The bundling of complementing transportation services into multimodal packages (also referred to as mobility-as-a-service schemes) could help fortify existing multimodal behavior, or retain it once the life situation changes. The enthusiasts might even act as service ambassadors, who promote shared mobility services like EBS in their communities.

- *Car-loving pragmatics* display a positive willingness and environmental motivation, but appear to have reservations about with shared transportation. This may be related to a lack of experience with such modes and lack of confidence. To encourage uptake, marketing campaigns highlighting the environmental benefits of ESS as well as improved well-being (incl. health, fun, positive emotions) could be effective. Additionally, a focus on what the car cannot offer might be important too, e.g. avoiding congestion, save parking cost/time. In a COVID-battered world, stressing the comparative safety of outdoor travel and fresh air (to this health and well-being aware user segment) might be perceived as offsetting the time cost and comfort offered by the car. A good service design and the convenience that goes with it are a goal for any service provider, but they might be particularly helpful with this group's transport needs. As a quarter in this group reported not owning a car, convenient connectivity to public transport would likely be of particular relevance. Importantly, addressing potential financial constraints with the prospect of saving money (as compared to mode alternatives including vehicle ownership). Onsite activities to try a pedelec and an EBS app could help overcome reservations (James et al., 2017).

- *Car-loving skeptics* appear to be the "hardest nut to crack". Data indicates many of them do not live near campus and might have to rely almost exclusively on their car for transportation. Offering individual advice on how and where to connect to public transport to reach their destinations could help address concerns about inconvenience and pricing. Promotional activities like pedelec trials may reduce their lack of experience with sharing systems, help them overcome their skepticism, and foster a more positive image. Safe cycling initiatives or training may help address concerns about riding in traffic. Since But ultimately, more coercive push measures like reduced or higher priced parking and encouragements like improved transit supply may be the only way to induce meaningful behavioral change. However, such measures would need to be very carefully applied, and may take a long time to realize. The high percentage of students of STEM subject in Cluster 1 may not be sample specific because other research has shown comparable results (Author, 2020). This should be considered when designing targeted interventions.

Some differences between the clusters appear to be systematic. The stark gap in *on/near-campus residence* between Clusters 1 and 3 deserves attention. This might indicate issues with the availability of affordable housing. Australian universities, including Griffiths, have much lower provision for on-campus accommodation compared to international peers in Asia, Europe and North America, with most domestic students living with their parents or in rental accommodation off-campus, and international students taking up the few on-campus residences or off-campus rentals. Increasing on-campus housing supply could help promote more sustainable travel behavior for people who study or work at universities. Housing location choice is also known to be influenced by mobility considerations and vice versa (Scheiner et al., 2016). For students, university study is a step into a different phase of life. Research has shown such events are opportunities to break with existing transport habits and form new ones (Klöckner, 2004; Scheiner et al., 2016). Hence, they present a window of opportunity for a transition to more sustainable means of travel. Encouraging and providing shared active transport may provide the pull needed to aid that transition.

It is striking that Australian citizens dominate Cluster 1 and are almost outnumbered by international students in Cluster 3. There is no indication this is income or age related. It is quite possible a different upbringing or a learned mobility culture play roles here (Götschi et al., 2017; Klinger et al., 2013; Leung and Le, 2019). Indeed, a divide is evident across multiple dimensions in several psychological and all mobility measures, as well as WA. Car ownership is higher in Cluster 1 (87% vs. 47%). Perceived compatibility, control, and social pressure are all lower and help explain the markedly lower intention to use ESS. This is accompanied by fewer positive WAs (e.g. environmentally friendly, convenient, save money) and more negative WAs (e.g. image, unsafe/unclean, unnecessary). Some of it might relate to the social stigma of cycling in general (Aldred, 2013) or the higher time-cost associated with using public transit (Li et al., 2015).

Our data confirms results from previous studies that students tend to be more multimodal (Limanond et al., 2011) and are more inclined to use active and public modes of transport (Shannon et al, 2006). Male students are more likely to use active modes (Davison et al., 2015). However, the greater propensity to use EBS by females and older people identified by Kaplan et al. (2018) in three driving-oriented Polish cities does not show in our data.

Since our data was collected, the COVID-19 pandemic emerged and lock-downs have affected urban mobility in major ways. Public transport is being avoided due to perceived infection risks because there is no solution to sealed air inside vehicles. In some cities, more personal modes including private motor vehicles, bicycles and e-bikes are surging as public transport declines. Global sales of e-bikes have grown massively in the first half of 2020 ("TheVerge," 2020; "Forbes," 2020; "Electrek," 2020). Some municipalities are grasping the opportunity of the disruption to make changes that are hard to achieve under normal circumstances by newly designating, widening or building additional cycling lanes, including in Brisbane. An ambitious e-mobility plan has been released, and EBS services are being rolled out in various Australian cities (e.g. Darwin and Gold Coast). While e-bikes, as a technological advancement that mean encourage cycling, its ownership and private use may not be affordable to less affluent members of society, who may struggle to maintain a private car and would normally rely on public transport. For the context of universities, this could include foreign students or those from low-income families. A public EBS service could fill that mobility gap and provide equitable access to safe and affordable transportation, overcoming the cost barrier pointed out by Jones et al. (2016).

6. Limitations and future research

Several limitations should be mentioned. The study only surveyed university students and staff; hence results are most applicable to a similar population. Future research could explore intentions of other population groups for different use cases of shared e-velomobility. It should be noted that presenting probabilities of cluster membership were not part of the core focus of this study.

The reasons for and against using EBS and the word associations indicated hedonic motivations, and emotional responses involving fun and pleasure, likely play an important role in bicycle use. This resonates with prior cycling literature (Passafaro et al., 2014). In our qualitative findings (WA and reason elicitation), this is reflected in aspects of well-being on the positive side. But similarly, there were statements regarding discomfort or hassle on the negative side. As Schwanen (2019, p. 6) pointed out, there are "social expectations and norms around sweat and bodily hygiene [that] make cycling unattractive for many workers". And while the university under investigation here actually provides end-of-trip facilities with showers and lockers on its campuses, these barriers to use remain, especially among the Australian citizens in our sample and among car-loving skeptics (Cluster 1). Pedelecs reduce the physical effort required to travel longer distances or up-hill with users less likely to need to shower or change at their destination. Only through trialing such modes may such advantages become obvious to skeptics. However, EBS is yet to be introduced at Griffith campuses. Research on actual e-bike uptake by investigating psychological determinants and their influence, or by observing and analyzing social practice can only be conducted when such happens, as neither is possible unless the material element (shared e-bikes) is present.

It is a limitation that our clustering uses behavioral intention and attitudinal variables as input. Nevertheless, studies focusing on sustainable behavior have shown the predictive power of psychological factors is higher than other influences like socio-demographics (Diamantopoulos et al., 2003; Jansson et al., 2011). Multimodality, as a social practice of transport, also includes potential uptake of EBS. Moreover, future research could utilize the intricate relationships between the psychological factors used in this study as theorized by behavioral models like value-belief-norm theory or behavioral reasoning theory. While research has shown intention is a good predictor of actual behavior, other factors that people have no control over may prevent adoption behavior (Sheeran, 2002). This leads to a so-called intention-behavior gap. We do not claim to have overcome the limitations of more traditional research approaches by accompanying psychological factors with qualitatively elicited context-specific reasons that relate to meaning, and word associations with EBS that convey emotions and motivational knowledge. But they did enable us to enrich the findings, and hint at the specific, contextual elements (materials, competence, meanings) that rule and force certain practices in the context of university campus related mobility.

While this paper was being developed, the introduction of dockless e-scooter sharing in Brisbane became popular and successful, with the docked CityCycle sharing scheme to be replaced by dockless e-bikes (Bland et al., 2021). The city of Gold Coast also introduced dockless e-bike sharing in December 2020. Nevertheless, the value of docked schemes should not be discounted, as it could offer easier management of parking and docked charging, especially in campus settings. It is noted the docked e-bike sharing schemes in Newcastle and Sydney are currently in place. In light of these developments, future research in the region could also consider actual usage behavior, as well as investigate potential adopters of a wider variety of micromobility offerings, be it docked, or dockless; bicycles or scooters.

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Appendix

Table A1. Latent variables, question items, loadings, reliability (N=368)

Latent variables	Mean	SD	Question items	Mean	SD	Loadings	CA	CR	Source
Intention to use EBS (INT)	5.29	1.27	INT1	4.826	1.616	0.890	0.846	0.907	Ajzen, 2002
			INT2	5.750	1.307	0.864			
			INT3	5.299	1.413	0.869			
Perceived Behavioral Control (PBC)	5.54	1.27	PBC1	5.747	1.369	0.865	0.833	0.899	Ajzen, 1991; Venkatesh et al., 2000
			PBC2	5.622	1.443	0.855			
			PBC3	5.247	1.585	0.875			
Attitude toward using EBS (ATT)	5.87	1.10	ATT1	5.910	1.163	0.949	0.872	0.940	Ajzen & Fishbein, 2005
			ATT2	5.837	1.181	0.933			
Subjective Norms (SN)	5.28	1.14	SN1	5.090	1.369	0.873	0.831	0.899	Amjad & Wood, 2009
			SN2	5.234	1.371	0.904			
			SN3	5.529	1.194	0.816			
Perceived Compatibility of EBS (COM)	4.69	1.35	COM1	5.458	1.324	0.796	0.790	0.878	Moore & Benbasat, 1991; Hahn et al., 2002; Kim et al., 2017
			COM2	4.476	1.615	0.896			
			COM3	4.141	1.864	0.825			
Reasons for using EBS (RF)	5.23	1.01	RF1	4.891	1.645	0.553	0.891	0.899	Westaby, 2005; Context-specific reasons were elicited based on an exploratory pre-survey, and items were developed drawing from Author, 2018; Claudy et al., 2015
			RF2	4.978	1.614	0.519			
			RF3	5.962	1.212	0.596			
			RF4	5.818	1.258	0.573			
			RF5	5.984	1.237	0.605			
			RF6	4.723	1.747	0.835			
			RF7	4.651	1.699	0.789			
			RF8	4.342	1.980	0.729			
			RF9	4.288	1.961	0.753			
			RF10	5.698	1.377	0.473			
			RF11	5.628	1.343	0.672			
			RF12	5.345	1.553	0.751			
			RF13	5.704	1.225	0.374			
Reasons against using EBS (RA)	4.45	1.11	RA1	4.614	1.777	0.630	0.891	0.899	
			RA2	3.541	1.879	0.439			
			RA3	5.046	1.804	0.443			
			RA4	4.516	1.831	0.566			
			RA5	4.429	1.790	0.560			
			RA6	3.986	1.777	0.750			
			RA7	4.842	1.735	0.499			
			RA8	4.715	1.861	0.508			
			RA9	4.709	1.755	0.703			
			RA10	4.134	1.771	0.587			

CA: Cronbach's alpha, CR: Composite reliability, literature.

Table A2. Results of the ordered logit regression with cluster membership as dependent variable

	Logit coefficients		Odds ratios	
VARIABLES	Estimate	SE	Estimate	SE
Dependent variable: cluster membership (1,2,3)				
Male	-0.157	(0.216)	0.854	(0.184)
Australian citizen	-1.523***	(0.372)	0.218***	(0.081)
Income > 350 AUD/week	-0.967**	(0.426)	0.380**	(0.162)
(Australian citizen) # (Income > 350 AUD/week)	1.215***	(0.471)	3.372***	(1.588)
STEM academic major	-0.647***	(0.205)	0.524***	(0.108)
Live on/near campus	0.619***	(0.220)	1.858***	(0.409)
Age > 29	-0.280	(0.264)	0.755	(0.199)
Graduated from higher education	-0.037	(0.233)	0.964	(0.224)
Owns no vehicle	-0.294	(0.375)	0.745	(0.279)
Driving license	0.067	(0.316)	1.070	(0.338)
/cut1	-2.488***	(0.518)		
/cut2	-0.308	(0.498)		
Observations	368			
Log pseudolikelihood	-370.74			
Wald Chi2(10)	40.20			
Pseudo R2	0.052			

Note: robust standard errors (SE) in brackets, *** p<0.01, ** p<0.05
# indicates interaction term; STEM = science technology engineering math; all variables binary

Table A3. Results of Brant test of parallel regression assumption

VARIABLES	**Chi2**	**p>Chi2**	**df**
All	3.55	0.965	10
Male	0.50	0.478	1
Australian citizen	0.05	0.831	1
Income > 350 AUD/week	0.06	0.803	1
(Australian citizen) # (Income > 350 AUD/week)	0.02	0.886	1
STEM academic major	0.00	0.976	1
Live on/near campus	0.17	0.681	1
Age > 29	0.95	0.329	1
Graduated from higher education	0.09	0.758	1
Owns no vehicle	0.03	0.873	1
Driving license	1.64	0.201	1

Note: A significant test statistic provides evidence that the parallel regression assumption is violated.

Table A4. Correlations between latent variables

	INT	**PBC**	**ATT**	**SN**	**COM**	**RF**	**RA**
INT	1						
PBC	0.574	1					
ATT	0.578	0.494	1				
SN	0.657	0.576	0.657	1			
COM	0.628	0.616	0.520	0.623	1		
RF	0.682	0.597	0.609	0.664	0.667	1	
RA	-0.360	-0.283	-0.244	-0.350	-0.422	-0.292	1

Note: all significant at $p<0.001$