What Makes a Commuter Cyclist? A Mixed Methods Study of Behavioural Antecedents and Perceptions of Commuter Cycling in the Wellington Region

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Abstract

Encouraging active transport contributes to both environmental sustainability and public health objectives. However, due to a myriad of physical, societal and personal factors, shifting car trips to the bicycle is notoriously difficult especially in societies where car use is deeply engrained in both the social and urban fabric. It is therefore important to explore novel approaches to promote utilitarian cycling.

Past studies have suggested there may be a link between cycling for recreation and cycling for transport. If this is the case, one could hypothesise that policies that promote recreational cycling may also indirectly promote utilitarian cycling.

This study begins to explore this important research question by investigating whether recreational cyclists are more amenable to utilitarian cycling than non-cyclists, using a case study of commuting in the Wellington Region of New Zealand.

Behaviour theory, based on the Theory of Planned Behaviour, provided the conceptual framework for a mixed methods analysis of Wellington Region commuters. Empirical modelling of commuter cycling behaviour showed that almost all antecedents of the behaviours of recreational cyclists are closer to those of commuter cyclists than to non-cyclists. Qualitative analysis provided further evidence that recreational cyclists are more prepared and willing to cycle their commute than non-cyclists.

It is concluded that, for the study sample, recreational cyclists are indeed more amenable to commuting by bicycle than non-cyclists in the Wellington region.

Key words: active transport, cycling, recreation, commuting, Theory of Planned Behaviour, perceptions, barriers, motivations, structural equation modelling

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Chapter 1: Introduction

1.1 Background

Utilitarian cycling is of value because it is a form of active transport and, as such, it is recognised as a key part of a sustainable transport system. Cities around the world increasingly need to adapt in response to climate change and peak conventional oil (Lindsay*, et al.*, 2011; Newman*, et al.*, 2009; Rissel, 2009). There is evidence that the peak of conventional oil production has passed and we now face rising fuel costs and the economic problems associated with this in car dependent societies (Chapman, 2013). Shifting to active forms of transport that do not rely on oil will help cities avoid such costs and be more resilient through increased energy independence (Newman, et al., 2009).

Climate change is arguably the biggest threat facing humanity and nature. Climate change mitigation requires a significant reduction in greenhouse gas emissions. To date emission reduction targets have not been met and global emissions continue to rise (IEA, 2012; IPCC, 2007). Private motorised transport is a major source of greenhouse gas emissions and reducing even short car trips, which could be achieved by replacing them with walking or cycling, would be beneficial. The active modes of transport create nearly no greenhouse gas emissions and could provide a significant contribution to meeting a nation's emissions reduction targets (Lindsay*, et al.*, 2011; Rissel, 2009).

Another issue facing much of the Western World is the rise in obesity and associated health problems to pandemic levels. Research shows that increasing obesity levels are due to a combination of high calorie diets and ways of life that promote inactivity, such as the use of inactive, motorised transport (Swinburn*, et al.*, 2011). The epidemic places a huge burden on health care systems and it leads to a reduced quality of life, as well as a reduction in lifespan and wellbeing (Oja*, et al.*, 2011; Wang*, et al.*, 2011). Active transport is a good way to combine exercise into a daily routine (Lindsay*, et al.*, 2011; Pucher & Dijkstra, 2003).

At a community level car dependent transport reduces community cohesion whilst active travel modes can increase informal social contact and create a stronger sense of community (Wood*, et al.*, 2010). Additionally, car dependence can lead to increased inequality because car ownership is expensive. Infrastructure dedicated to car transport privileges the wealthy who can afford cars but it does not provide for members of the community whose only transport is public or active modes (Goodman*, et al.*, 2012). Furthermore, widespread car use can reduce access and mobility for those who have no choice but to go by car, for example the elderly and people with disabilities (Aldred & Woodcock, 2008).

All of these costly problems can be addressed through promoting cycling. Exercise through active transport decreases stress, increases productivity, and helps communities to interact. This in turn improves people's health, with a greater quality of life (de Hartog*, et al.*, 2010; Oja*, et al.*, 2011; Pucher & Dijkstra, 2003). Costs to health care systems are lessened (Powell*, et al.*, 2010) and the local economy in general benefits as less money is spent funding motorised travel (which is generally lost from local economies), so more money is available to be spent within the community. A further economic benefit to promoting cycling is that more money is put into the local cycle industry (Davis, 2010; Gotschi, 2011; Grous, 2011; Krizek, 2007; Litman, 2004).

1.1.1 Cities and Cycling

The benefits of increasing the mode share of active transport are well researched (Davis, 2010; de Hartog*, et al.*, 2010; Gotschi, 2011; Grous, 2011; Oja*, et al.*, 2011). There are a number of cities around the world that are making a concerted effort to provide for people who cycle and hence increase cycling mode share. Many of the cities leading the way are in Europe and include Copenhagen, Amsterdam, London, Barcelona and a number of German towns and cities (Pucher & Buehler, 2008a, 2008b; Pucher & Dijkstra, 2003; Pucher*, et al.*, 2010; TfL, 2013). There has also been a considerable push in North America with places such as New York, Portland and Montreal investing significant amounts of time and money into cycling facilities (NYC DOT, 2012; Pucher, Buehler*, et al.*, 2011). In the Southern Hemisphere Melbourne has created networks of cycle lanes and paths and provides a bicycle sharing system for the public (Pucher, Garrard*, et al.*, 2011).

There has also recently been some significant investment in cycling in a few cities in New Zealand, primarily, the investment of $7.28 million in Hastings and New Plymouth by the New Zealand Transport Agency (NZTA) as part of their Model Communities Programme to promote walking and cycling (NZTA, 2010). However, nationally, cycling remains a minority transport mode in terms of percentage of trips made by bicycle, with cycling accounting for only 1.4% of the total number of trip legs in New Zealand in the latest Household Travel Survey (Ministry of Transport, 2013a). The mode share and ownership rates of cars also highlights that New Zealand is highly car dependent: 79% of total travel time and 78% of total trip legs are made by car or van (Ministry of Transport, 2013a), with ownership levels of 682 light passenger vehicles per thousand people (Ministry of Transport, 2013b). The dominance of the car is further demonstrated by the difference in the amounts of money spent on car infrastructure and active transport facilities by the government. In the 2012 to 2015 National Land Transport Programme, NZD 4,370 million is allocated to road infrastructure and NZD 79 million for walking and cycling facilities (NZTA, 2012b). When other expenditure, such as that for road maintenance and road policing, is included the amount spent on motorised vehicles more than doubles (NZTA, 2012a).

My interest is in exploring ways in which utilitarian cycling can be further encouraged and promoted in New Zealand with a view to identifying options that have not yet been fully exploited and which may increase public acceptance and interest in utilitarian cycling. In particular I wish to explore the link between recreational cycling and the acceptance of utilitarian cycling as a mode of transport. For the purposes of this research, recreational cycling is defined as any cycling that is not for transport.

1.2 Literature Review

A study of the peer-reviewed literature reveals that significant work has been done on the benefits of cycling, as discussed above, and there is general agreement that cycling is beneficial to individuals, societies and economies and that it should be promoted (Davis, 2010; de Hartog*, et al.*, 2010; Gotschi, 2011; Grous, 2011; Heinen*, et al.*, 2010; Kingham*, et al.*, 2011; Oja*, et al.*, 2011; Pucher*, et al.*, 2010). There has also been some research into the barriers to cycling that exist and strategies to overcome these barriers. Much work still needs to be completed in this area, but a review of the literature shows an even greater deficiency in work that has been done on the link between utilitarian and recreational cycling.

1.2.1 Barriers to Cycling

In their extensive review of the literature on cycling, Heinen *et al* (2010) identify a number of different barriers to cycling for transport. Such barriers include safety, both actual and perceived; high traffic levels; bad weather; comfort; inconvenience; experience, confidence or competence on a bike; time and distance perceptions; local topography, for example hills; problems with trip-chaining or combining journeys; insufficient infrastructure; and the fact that cycling is an uncharacteristic mode of transport whereas cars are easier, convenient and 'normal' (Heinen*, et al.*, 2010; Kingham*, et al.*, 2011). Pooley *et al* (2011) also highlight the effects of non-physical, personal and social barriers on utilitarian cycling uptake. Many of these barriers relate to perceptions of potential problems and so are very subjective and affect individuals to varying extents. As is perhaps to be expected, recent research has found that people who do cycle for recreation or utilitarian purposes perceive these barriers to be much lower than those who do not (Bamberg & Schmidt, 1994; de Geus*, et al.*, 2008; Gatersleben & Appleton, 2007; Koorey*, et al.*, 2009; Stuckless, 2010).

A research report published by the NZTA discusses the importance of these barriers to potential cyclists. It was found that while barriers such as the lack of showering facilities at the destination, minimal enjoyment of the journey and the discourtesy of car drivers were significant issues that could stop individuals from cycling to work, the biggest barrier facing potential cyclists was perceived safety (Kingham*, et al.*, 2011).

1.2.2 Promoting Cycling

The motivational factors for cycling are just as varied as the barriers in terms of what they are and how they affect individuals. These include health and fitness, convenience, enjoyment of the journey, flexibility, environmental consciousness, fuel costs and time savings (Heinen*, et al.*, 2010; Kingham*, et al.*, 2011). These motivations are important because they provide a target for cycling promotion interventions to focus on in order to improve their effectiveness (Stuckless, 2010).

There are two types of policy measures that can be employed by councils or governments to promote cycling. These are termed hard and soft measures. Hard policy measures include the installation of cycle lanes, showering facilities and bicycle parking and storage facilities. These measures generally address barriers to cycling, such as safety and inconvenience, and the provision of a network of fully segregated cycle paths has been shown by Koorey *et al.* (2009), using stated preference, to be the favoured promotion strategy of potential cyclists. Soft policy options usually involve trying to change people's perceptions of barriers and increase the prevalence of motivations to cycle. Sometimes these also involve increasing barriers to car use and include advertising campaigns, education programmes and traffic demand management (Kingham*, et al.*, 2011; Pucher*, et al.*, 2010).

There have been very few comprehensive studies that have carried out a full, objective analysis of the effectiveness of cycling promotion strategies and as a result firm conclusions are hard to draw and further research is required. In their review Ogilvie *et al* (2004) found that isolated strategies did not appear to make a significant difference to cycling numbers. However Pucher *et al* (2010) found, through their review of international cycling promotion programmes, that while there is currently little evidence to prove that these interventions have a positive effect on cycling numbers on their own, when they are combined into a comprehensive promotion strategy they are more effective.

1.2.3 Characteristics of (Potential) Cyclists

Studies on behaviour change have shown that removing the barriers (whether real or perceived) to an action is not always enough to create the desired behaviour change; internal motivations are also required (Gifford, 2011). This suggests that simply removing barriers to utilitarian cycling, for example by installing cycle lanes, may not be enough to significantly increase cycling numbers. It is also necessary to create interest or desire. As stated by Koorey *et al* (2009) "*... people interested in cycling have several motivations encouraging them to investigate utilitarian cycling and have usually overcome obvious barriers...*" (p10).

Social norms, attitudes and habits also play a large part in shaping people's travel intentions and choices. Heinen *et al* (2010) conclude that if a person has a positive attitude towards cycling and is already in the habit of cycling for recreation then they are more likely to commute by bicycle. It has also been suggested that if cycling becomes more popular more non-cyclists might become responsive to policy interventions to promote commuter cycling (Gatersleben & Appleton, 2007; Stuckless, 2010). This demonstrates the importance of changing social norms and attitudes towards cycling and portraying positive cycling messages (Heinen*, et al.*, 2010; Stuckless, 2010).

In support of this, studies have indicated that many commuter cyclists were first recreational cyclists (Sener*, et al.*, 2009) and that many recreational cyclists also commute (Koorey*, et al.*, 2009). Recreational cyclists have also been identified as good targets for utilitarian cycling promotion campaigns as it may be easier to change their transport behaviour in favour of cycling (Stuckless, 2010). Additionally, Stinson and Bhat (2004) have shown that cycling in one's free time is associated with a higher frequency of utilitarian bicycle trips. Therefore, as stated by Howard and Burns (2001), recreational and commuter cyclists are not independent groups. However, the link between recreational cycling and utilitarian cycling is under-researched and it has not yet been established whether, and under what conditions, recreational cyclists progress to utilitarian cycling (Kingham*, et al.*, 2011; Lumsdon, 1997).

1.3 Research Gap

As has been shown, there are many gaps in our understanding of how utilitarian cycling can be most effectively promoted. Specifically, the role of recreational cycling in utilitarian cycling promotion strategies is unclear.

One could hypothesise that promoting the fun and enjoyable aspects of recreational cycling might bridge the gap between being not interested in cycling at all and choosing to cycle for transport. As outlined above, it is important to get more people cycling for transport purposes. The installation of segregated cycle lanes is widely seen as a necessary measure and is cited as the most desired intervention by potential cyclists, but this is expensive and requires significant levels of support from the public. By promoting recreational cycling and increasing the pool of people interested in cycling there may be more political will, and therefore more resources, to support cycling promotion strategies. This in turn may allow more expensive interventions, such as the installation of cycle lane networks, to be carried out and hence further increase the uptake of cycling and accelerate the transition towards a sustainable active transport system.

There are a number of aspects that need to be understood in order to determine whether promoting recreational cycling would be an effective strategy for increasing utilitarian cycling levels. Firstly, it would be necessary to determine whether recreational cyclists are more amenable to utilitarian cycling than non-cyclists. If this is shown, it would suggest that encouraging recreational cyclists to take up utilitarian cycling would be easier than encouraging non-cyclists. The next step would be to evaluate how to effectively promote recreational cycling to non-cyclists and then to look at how the 'spill over' from recreational cycling to utilitarian cycling can be further encouraged.

To address all these questions would require a substantial amount of research and is outside the scope of this master's thesis. This present study does, however, aim to contribute to illuminating this broader research question by addressing the first step described above.

1.4 Study Context

The Wellington Region of Aotearoa New Zealand is situated at the southern end of the North Island, with an estimated population of 490,100 in mid-2012 (Statistics New Zealand). It consists of eight districts (as shown in Figure 1) with the majority of the population located in Wellington City, Lower Hutt City, Porirua City, Kapiti District and Upper Hutt City. It also contains New Zealand's capital city, Wellington.

The Wellington Region has a temperate climate, with average daily temperatures slightly above the national average, and average rainfall slightly below the national average. Wellington is, however, renowned for wind with more and stronger windy days than the national average (Maclean, 2013). As Figure 1 suggests, parts of Wellington are hilly; however most of the urban centres are concentrated on flatter ground.

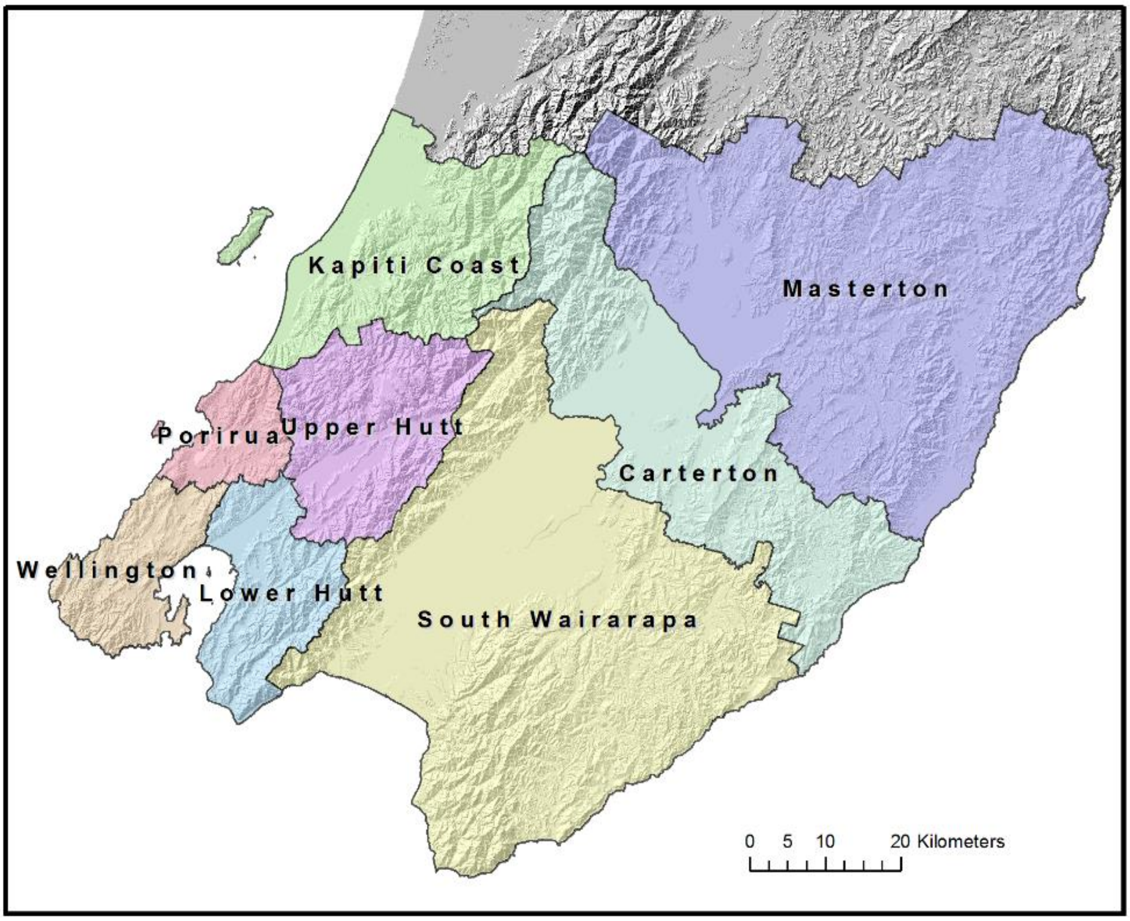

Figure 1: Map of the Wellington Region showing the Territorial Authorities and terrain of the Region[1]

Transport cycling levels are low in the region, with one per cent of trips made by bicycle in the 2007-2011 period. However, the Wellington Region has seen a steady increase in the number of people cycling each year from 2003 to 2011 (Greater Wellington Regional Council, 2013), with Wellington City being the only major New Zealand city to record a continuous increase in the number of workers cycling to work on Census day from 1986 to 2006[2] (Figure 2) (Koorey*, et al.*, 2009). The Wellington City Council attributes this increase to "*the intensification of Wellington's inner city and surrounding suburbs along with improvements to cycle technology and an awareness of health and climate issues*" (Wellington City Council, 2008, p. 2).

[1] Created by Author using ArcGIS software by Esri. Data from Statistics New Zealand (2006a) and Geographx (2013).
[2] The 2006 Census was the most recently released Census at the time of writing. A census was carried out in 2013, but the data have not yet been released to the public.

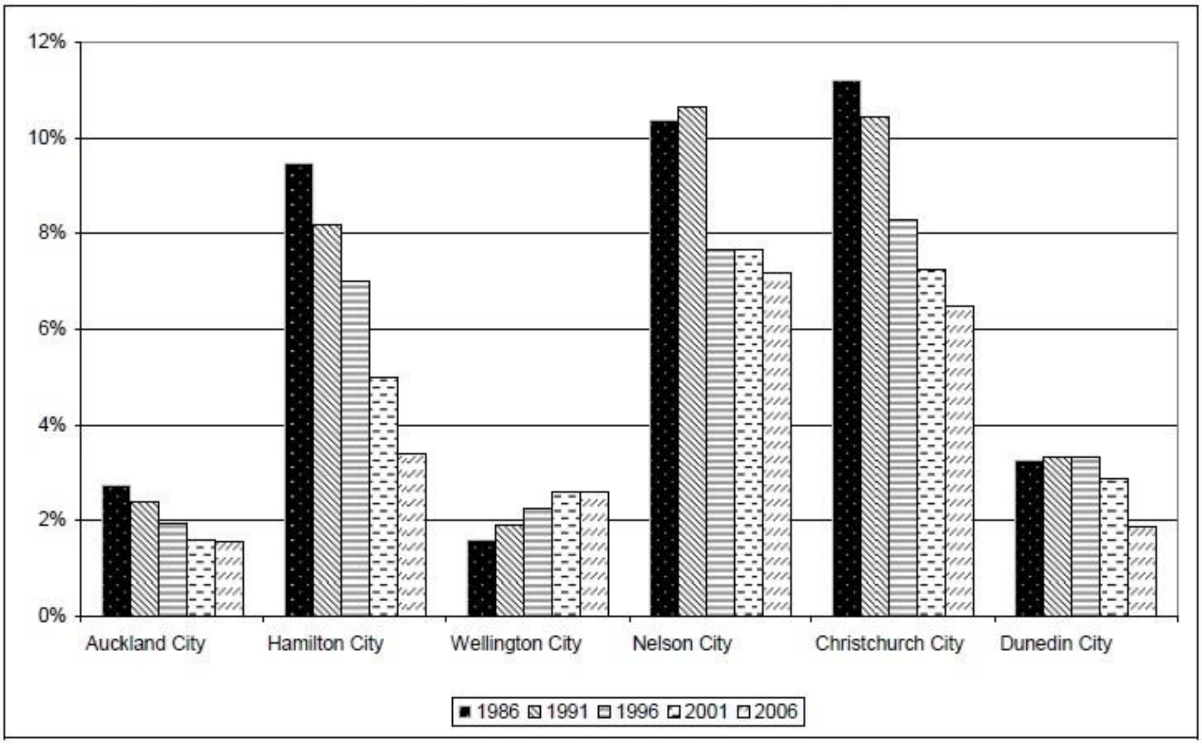

Figure 2: Proportion of workers cycling to work on census day 1986-2006, from Koorey, et al. (2009, p. 3)

In the financial year 2010/11 there was NZD 865,000 spent on cycling facilities and infrastructure in the region, with approximately NZD 400,000 of this coming from local government and the remainder coming from the National Land Transport Fund, via the NZTA. This amount equated to 0.2% of the National Land Transport Fund in this period (Greater Wellington Regional Council, 2013, p. 24). NZTA figures show that there were approximately 41km of on-road cycle ways in the region in 2011, down from approximately 57km in 2010. The majority of the policy support for transport cycling from the Regional Council comes in the form of promotion and encouragement, through programmes such as 'Active a-2-b' and 'Spring to the Street', which encourage people to take active transport to work, and cycle skills training (Greater Wellington Regional Council, 2013). At the city level there is less support, with Wellington City Council stating that it will not actively encourage transport cycling until it is safe:

> *[T]he risk involved with cycling is high… Making cycling safer and more convenient is expected to increase its popularity. If successful, future plans will then be able to set targets for increasing cycling numbers.* (Wellington City Council, 2008, p. 3)

The council recognises that some people choose to cycle and will support them by providing shared bus and cycle lanes:

> *[T]he Council's Transport Strategy 2006… encourage[s] walking and public transport as the foremost modes of transport but recognises some people prefer to cycle. The policy aims to support these people through the promotion of a safe and convenient network but also aims to ensure conflicts between different groups is managed appropriately.*
>
> *… [C]yclists will have access to and be encouraged to use as many bus routes as possible* (Wellington City Council, 2008, p. 2).

There are, however, significant recreational cycling facilities in Wellington. Extensive off-road trail networks have been created around the region. This has been achieved predominantly by the work of volunteers from the many mountain bike clubs and trail building organisations in the area, but facilitated by the support of a number of the territorial authorities, including Wellington City Council and Hutt City Council, as well as the Greater Wellington Regional Council. These trails are developing rapidly and the Wellington City Council has an ambition to make Wellington a "world class" destination for mountain biking (Wellington City Council, 2013).

There are also significant investments in the National Cycle Trail network in the region, including the ongoing construction of The Great Harbour Way, which provide valued facilities for recreational cycling for families and road cyclists. Additionally, the region has a number of road cycling clubs that actively promote social road cycling as well as holding regular competitive and social events and organising various local road race series.

This level of support has seen cycling become one of the more popular recreational activities in the Wellington Region, with over 100, 000 adults (or 28.7% of the Region's population) reported to have participated in recreational or sport cycling in the 12 month period of the latest Active NZ Survey (Sport and Recreation New Zealand, 2009).

The difference in levels of support and provision for recreational cycling and commuter cycling makes the Wellington Region an interesting place to study the link between these two forms of cycling. This study has focussed on the Wellington Region to shed light on whether the Wellington City Council is correct in attributing the increases in commuter cycling to intensification, technology improvements and an awareness of health and climate issues, or whether these increases may, at least in part, be due to the high level of recreational cycling in Wellington.

1.5 Aim

The aim of this research project is, therefore, to determine whether recreational cyclists are more amenable to commuting by bicycle than non-cyclists in the Wellington Region.

The following chapter explores the theory used to investigate this topic and thus sets out the specific research questions to address the aim. Chapter 3 outlines the methodological approach and explains how the data were collected and analysed to address each research question. Chapter 4 then presents the findings of the quantitative and qualitative data analysis. In the final chapter, the findings of this research are discussed and interpreted in light of the literature.

Chapter 2: Theory

To examine whether recreational cyclists are more amenable to commuting by bicycle than non-cyclists, it is necessary to have an understanding of human behaviour and its antecedent conditions. Through this, it may be possible to begin to understand whether or not recreational cycling may be a 'gateway' into utilitarian cycling.

As such, this section firstly reviews the prominent literature on human behaviour theories. As this is a vast body of work the review focuses on the subjective factors that create and precede behaviour in individuals, as opposed to a focus on how behaviour can be changed or how completely objective factors may shape behaviour.

Secondly, this section reviews the recent use of behaviour theory in transport research, with a focus on utilitarian cycling in particular. Lastly, this section draws together the key findings of the review to propose a conceptual model of individual behaviour to be applied to commuter cycling for this research.

2.1 Theories of Behaviour

2.1.1 Rational Choice

One of the most influential and far-reaching models of human behaviour is the Expectancy Value model based on rational choice theory. This theory underpins Western neoclassical economics and as such is widely used to explain behaviour and justify policies (Jackson, 2005). It is based on the assumption that people make deliberate and reasoned choices which maximise their personal utility. To do this, people must know what the outcomes of all possible actions will be so they can then attach value to such outcomes, thus allowing them to weigh up the costs and benefits of each choice (van den Bergh, *et al.*, 2000). Any social behaviour that occurs arises from individuals maximising their own utility, which may or may not happen to coincide with the social good (Scott, 2000; van den Bergh, *et al.*, 2000). Rational individual choices that lead to optimal outcomes require a ‘perfect market’ and therefore, the possession of full information on all possible choices (van den Bergh, *et al.*, 2000).

This model, however, has proven to be very limited for predicting or explaining behaviour, especially pro-environmental or socially motivated behaviour and regularly repeated habitual activities, such as transport mode choice (van den Bergh*, et al.*, 2000). Furthermore, this theory does not fully account for non-market aspects of individual preference and also assumes that demand for goods and services is unlimited, if the benefits outweigh the costs (Scott, 2000). Individuals rarely have the time or mental capacity to gather full information and cognitively process all options. Additionally, uncertainties are always present; therefore fully rational choices are illusory (Jackson, 2005; van den Bergh*, et al.*, 2000).

People have biases or predetermined preferences towards certain behaviours, including affective (emotional) responses not based on reasoned thought but based on past behaviours and experiences. An example of this is habits, which are very important as they save on transaction costs of deliberation about action, but can sometimes result in behaviour that does not maximise personal benefit (van den Bergh*, et al.*, 2000). Additionally, people often act socially where their behavioural choice is based on benefit to others or the environment. Many individual decisions are shaped and constrained by social context, norms and morals, which cannot be explained by rational choice theory (Jackson, 2005; Scott, 2000; van den Bergh*, et al.*, 2000).

2.1.2 Theory of Reasoned Action

The Theory of Reasoned Action was proposed by Ajzen and Fishbein (1980) as a way to account for some of the behaviour that Expectancy Value models could not. It was a widely applied social behaviour theory that is still based on rational choice, but includes influences of an individual's beliefs and subjective norms (Jackson, 2005). The rational choice component is where an individual's attitude towards a behaviour is formed from beliefs about the outcomes of an action and the values that they attach to those outcomes (Jackson, 2005). Additionally, what the individual believes others, whose opinion they value, think they should or should not do forms the subjective norm. This subjective norm is therefore dependent on what others might think. These two factors (attitude and subjective norm) combine to create an intention to behave in a certain way, which directly leads onto a behaviour (Ajzen, 1991).

This model retains many of the flaws of rational choice, as it still does not fully incorporate social norms, emotional biases or habits. Furthermore, studies have shown that the correlation between intention and behaviour is not perfect. These factors are only well correlated when the individual feels that they have control over their behaviour. To account for this Ajzen modified this theory to produce the Theory of Planned Behaviour (Ajzen, 1991; Jackson, 2005).

2.1.3 Theory of Planned Behaviour

The Theory of Planned Behaviour (Ajzen, 1991) is an adaptation of the Theory of Reasoned Action to account for situations where the individual does not have complete freedom to control their behaviour. As such, this theory incorporates Perceived Behavioural Control (PBC) into the model set out in the Theory of Reasoned Action (see Figure 3).

PBC "refers to people's perception of the ease or difficulty of performing the behaviour of interest" (Ajzen, 1991, p. 183) and is an indicator of both intention and behaviour (Ajzen, 1991; Jackson, 2005). Ajzen posits that if PBC closely matches *actual* behavioural control an intention to behave will lead to action. However, if people do not have control over their behaviour, whether perceived or actual, then they will not change their behaviour (Ajzen, 1991). For example, if people do not feel that they can change the way they get to work then they will have no intention to do so.

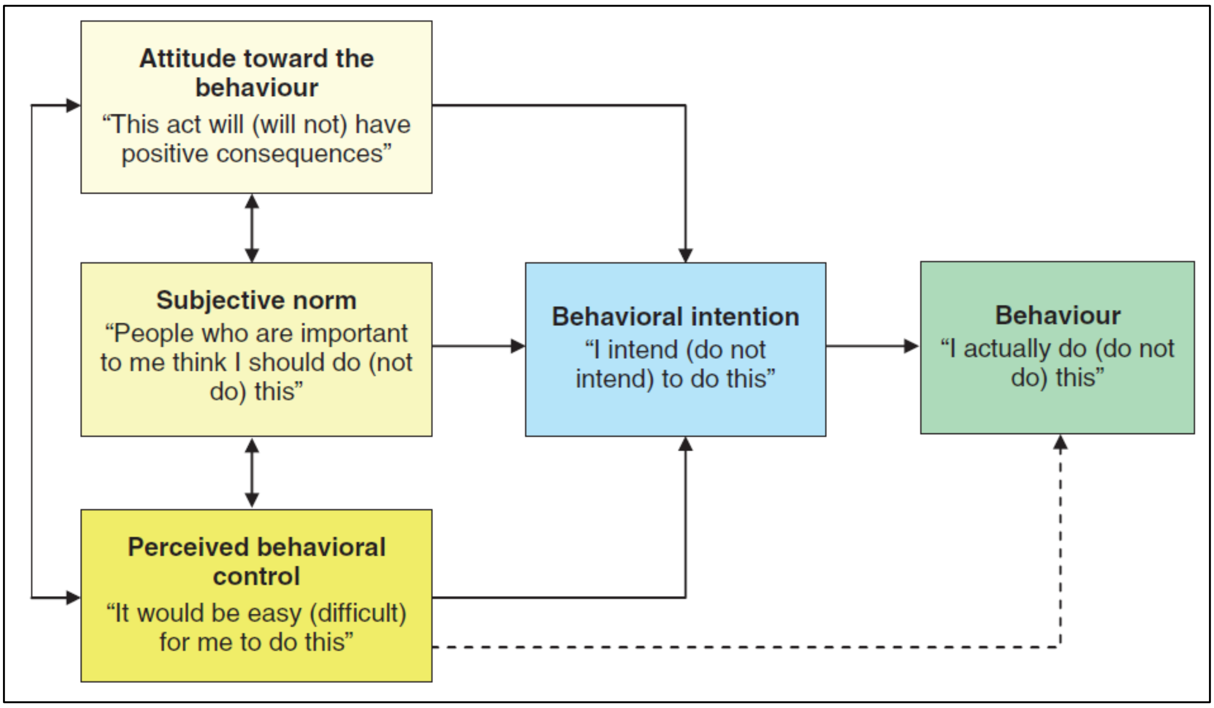

Figure 3: Ajzen's Theory of Planned Behaviour (From Gifford, et al., 2011, p. 804)

The Theory of Planned Behaviour is the most frequently used model for examining pro-environmental behaviour, such as travel mode choice (Bamberg & Schmidt, 2003). This model does incorporate emotional, social and moral factors of behaviour to a (somewhat limited) degree, but only as far as they affect that person's attitude towards a behaviour and their PBC. There is still no significant focus on social, moral and emotional factors or habits (Bamberg*, et al.*, 2003; Jackson, 2005).

2.1.4 Norm-Activation Theory

The Norm-Activation Theory (Schwartz, 1977) provides a model for altruistic behaviour based on personal norms. Personal norms are what the individual believes they should or should not do irrespective of what others believe. These personal norms are formed from an awareness of the consequences of actions and a feeling of responsibility associated with these consequences. They are not based solely on what the individual believes others will think of their actions, as is the case with subjective norms (Bamberg & Möser, 2007).

As well as influencing an individual's personal norms, awareness and responsibility also directly affect behaviour. The greater awareness and sense of responsibility a person has, the stronger the link between personal norm and behaviour (Jackson, 2005). This model has been used by Bamberg and Schmidt (2003) and adapted by Bamberg and Möser (2007) to analyse transport choices. However, research has shown that the correlation between personal norm and behaviour is strongly influenced by contextual factors (Jackson, 2005; Stern, 2000).

2.1.5 Value-Belief-Norm Model

The Norm-Activation Theory has been expanded by Stern in his Value-Belief-Norm model to include the values and beliefs of the individual that directly affect the person's awareness of consequences and ascription of responsibility (Stern*, et al.*, 1999). This adaptation has made this model more accurate at explaining behaviours of a pro-environmental nature (Stern, 2000). However, evidence still showed a weak correlation between personal norm and pro-environmental behaviour, indicating the importance of situational and contextual factors (Stern *et al*., 1999; Jackson, 2005).

There is also little explicit consideration of social norms, which have been shown to have a definite effect on behaviour and, therefore, should be factored in (Jackson, 2005).

2.1.6 Focus Theory of Normative Conduct

One theory of behaviour that explicitly relates social norms to individuals' actions is Cialdini's Focus Theory of Normative Conduct (Cialdini*, et al.*, 1991). This theory sets out that social norms directly influence an individual's behaviour and distinguishes two types of social norm (Jackson, 2005).

Firstly, descriptive norms are what others do. Their effect is seen when individuals copy what they see others do. This type of norm helps reduce the need for cognitive processing of behaviour choices. Secondly, injunctive norms are perceptions of what ought to be done. These are present when individuals behave in accordance with what society believes should or should not be done. This is similar to the subjective norm of the Theory of Reasoned Action and the Theory of Planned Behaviour, but includes a wider set of moral rules (Cialdini*, et al.*, 1991).

These two types of norms can conflict. Therefore, the Focus Theory of Normative Conduct states that behaviour depends on which norm is most prominent at the time of action. Behaviour is also based on how each individual responds to these types of norms, which is dependent on their "personality, situation and personal norms" (Jackson, 2005, p. 60). As such, modelling behaviour using this theory is very difficult and complex (Jackson, 2005).

From looking at the limitations of the models discussed so far it is clear that two major influences on individual behaviour remain to be considered. These two influences are habits and the broader social context in which decision-making occurs. These are now discussed, followed by an examination of the theories and models that attempt to incorporate these influences.

2.1.7 Habits

As has been mentioned earlier, behaviour is clearly not always determined by 'cognitive deliberation' or intention. People form habits to save time and energy spent on mentally processing every task. Habits are effectively efficiency improvements that require little, if any, conscious processing, and have been shown to be very important in transport mode choice (Aarts*, et al.*, 1997; van den Bergh*, et al.*, 2000).

Habits are strengthened by the regularity of carrying out the action in question. The more frequently an action is performed the stronger the habit becomes and the harder it is to break, or change it. Actions that are repeated every day, for example driving a car to work, can become deeply entrenched and can be very difficult to change (Verplanken*, et al.*, 1997; Verplanken*, et al.*, 1998).

This, combined with the differences in short-term and long-term rewards, mean that habits can be hard to break even when it is clear that, in the long term, it would be beneficial for the individual to do so (Schwanen*, et al.*, 2012).

2.1.8 Society and the Social Context

The broader social context is an important influence and constraint on individual behaviour (Bamberg*, et al.*, 2007; Jackson, 2005). People tend to form social groups and identities that have varying social norms. This can lead to competition between groups, which further alters or influences individual behaviour (Ostrom, 2000). Additionally, individuals often portray certain images of themselves that they want society to see. When differences arise between what an individual feels they should do, and what they actually do, cognitive dissonance can occur. This leads to the alteration of either the behaviour or beliefs in order to correct these differences (Dawnay & Shah, 2005).

There have been a number of attempts to integrate the influences of habits and context into behaviour theories. But, while they can help improve our understanding of the processes that determine behaviour, often they become too complicated to be used in specific empirical analyses (Gifford*, et al.*, 2011; Jackson, 2005). Nonetheless, it is not possible to ignore such factors as habit and societal influences when attempting to examine behaviour. As Stern points out, a model of behaviour should cover attitudes, contextual factors, personal capabilities and habits (Stern, 2000, in Jackson, 2005, p. 93).

2.1.9 Attitude-Behaviour-Context Model

In Stern's (2000) Attitude-Behaviour-Context (ABC) model, behaviour is determined by how two broad categories of factors interact. These two categories are attitude and external conditions. Attitudes are formed by factors such as specific personal beliefs, personal norms and values, and a tendency to act in a certain way, which covers emotional responses and biases. External conditions, or contextual factors, cover financial, institutional and legal factors, physical capabilities, social norms and other interpersonal issues, as well as social contextual issues, such as group allegiances (Jackson, 2005; Stern, 2000).

This model proposes that when contextual factors are weak, attitude plays a very important role in determining behaviour. But when contextual factors are strong in relation to a certain behaviour, attitude is not so pivotal (Jackson, 2005). While this model pays more attention to social and contextual factors it still does not account for past behaviours and habits (Stern, 2000).

2.1.10 Theory of Interpersonal Behaviour

Another theory that tries to incorporate all of these factors is the Theory of Interpersonal Behaviour from Triandis (1977) (See Figure 4). In this model, intentions immediately precede behaviour, as seen in the theories of Reasoned Action and Planned Behaviour. However, habits are also shown to influence behaviour alongside intentions. Additionally, the effects of both of these factors are controlled by contextual factors or 'facilitating conditions' (Jackson, 2005; Triandis, 1979).

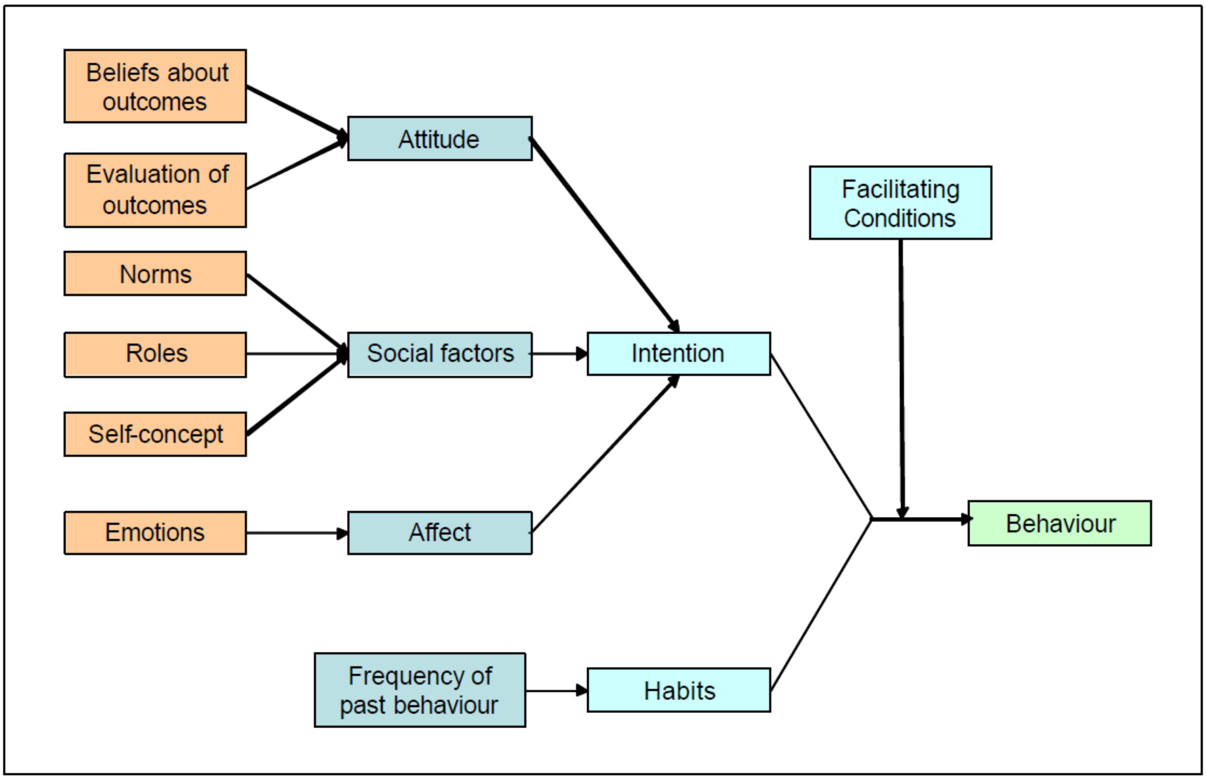

Figure 4: Triandis' Theory of Interpersonal Behaviour (From Jackson, 2005, p. 94)

According to Triandis (1977), behaviour is a result of a combination of intention, which is mediated by attitude, social factors and emotions; habits, whose strength depends on the frequency of past behaviour; and the context through which the person is living.

Therefore, behaviours are influenced by society and social norms; emotional responses; past behaviours; personal beliefs about the individual's role in society, norms and morals; as well as deliberative thought. The norms mentioned in this theory are similar to those of Cialdini's Focus Theory of Normative Conduct. 'Roles' relates to social identity and the role of the individual within society. Affect incorporates an individual's instinctive preferred response to a situation (Bamberg & Schmidt, 2003; Jackson, 2005).

Studies, such as by Bamberg and Schmidt (2003), have shown that although this model is more complex than others, such as Stern's ABC model, the Norm-Activated Model and the Theory of Planned Behaviour, it is more comprehensive at explaining observed behaviour. Of particular importance to the ability of this model to explain transport behaviour, compared to other models, are role beliefs and habits (Bamberg & Schmidt, 2003).

2.1.11 Motivation-Opportunity-Ability Model

Another relevant behaviour model is that developed by Ölander and Thøgersen (1995). The Motivation-Opportunity-Ability Model is very similar to Triandis' Theory of Interpersonal Behaviour, but additionally, includes feedback loops (Jackson, 2005).

This model merges the Theory of Reasoned Action with the ideas of ability and opportunity to perform the behaviour in question. Ability includes habits and whether the individual has knowledge about how to perform the task (similar to PBC). Opportunity includes contextual factors and conditions. This Opportunity factor can represent actual behavioural control.

The Motivational component of the Theory of Reasoned Action can be exchanged, as necessary, with other models, including the intention section of the Theory of Interpersonal Behaviour (Jackson, 2005; Ölander & Thøgersen, 1995).

As shown in Figure 5, the Motivation-Opportunity-Ability Model also shows that the resulting behaviour of all of these factors feeds back to influence ability and the evaluation of beliefs. This 'feedback' is something that has not been explicit in the other models, but has been implied. While this may make the model more realistic, it makes using the model in an empirical way much more difficult.

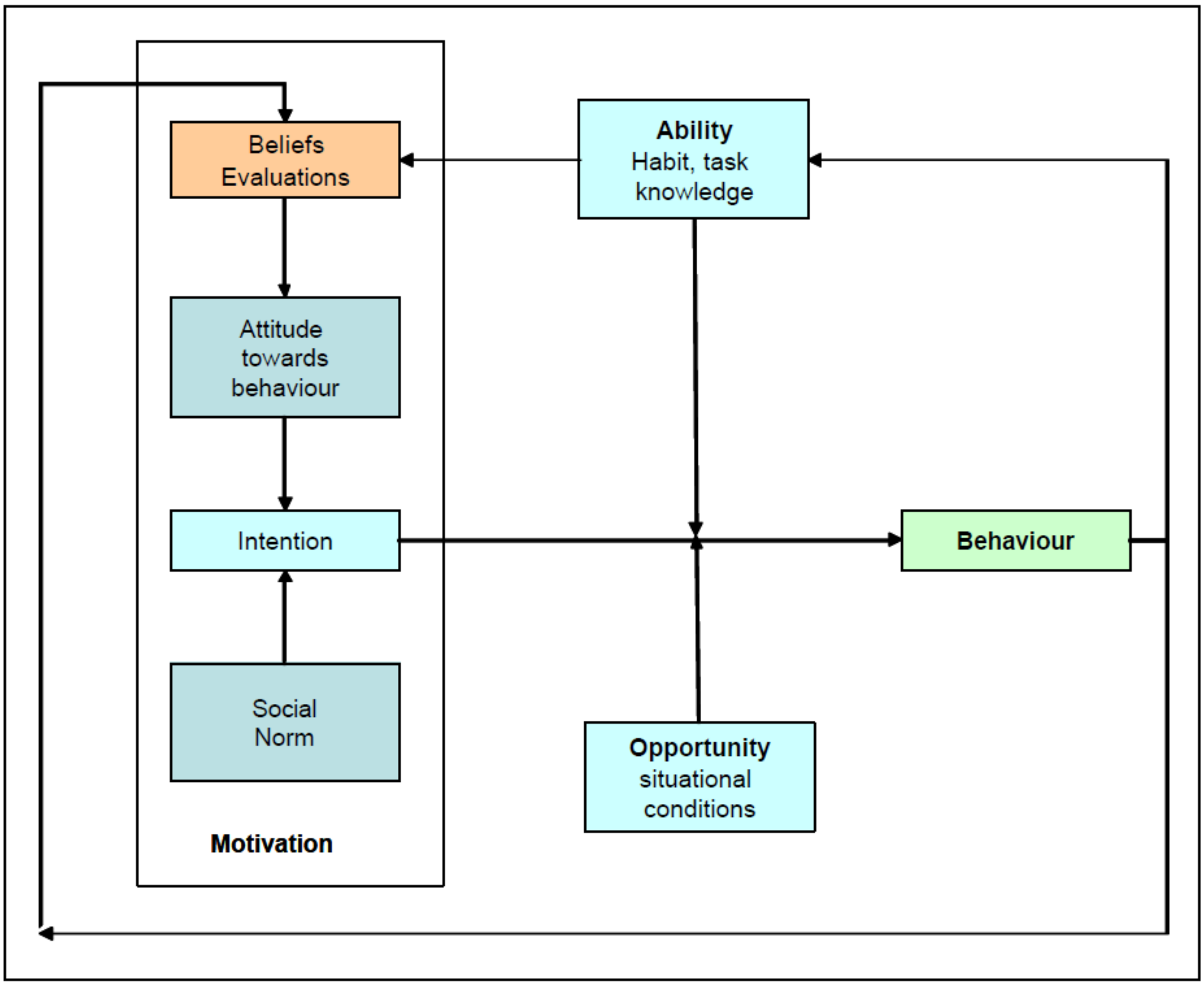

Figure 5: Ölander and Thøgersen's Motivation-Opportunity-Ability Model (From Jackson, 2005, p. 96)

The Motivation-Opportunity-Ability model has mostly been applied for use in public transport research, such as in Thøgersen (2006) and Thøgersen (2009), and energy savings interventions, for example studies by Abrahamse*, et al.* (2005) and Gatersleben and Vlek (1997) (Jackson, 2005).

There have been many more models and theories of behaviour developed over the years, including much more detailed attempts such as Bagozzi's Model of Consumer Action (Bagozzi*, et al.*, 2002) and the Integrated Behaviour Model by Kasprzyk *et al.* (1998). Bagozzi's model shows links between unconscious processes, attitudes, expectations, norms, PBC, social conditions, situational factors and other influencing antecedents and while it does provide a sophisticated and detailed understanding of what might contribute to behaviour, it is too complicated to be easily used for empirical study and has, so far, not been applied, to the author's knowledge (Jackson, 2005).

2.2 Behaviour (Change) Theory in Transport Research

Thus far, the focus has been on prominent individual behaviour theories, not necessarily those applied in the transport domain. We now turn to the latter. Much of the research into travel mode choice and active transport uptake has looked at the effectiveness of specific interventions to change travel behaviour. This is usually done in a pragmatic manner and so has often not been based on behaviour theory (Schwanen*, et al.*, 2012).

The travel behaviour literature that has been grounded in theory is predominantly based on one of three main models, the Theory of Planned Behaviour, the Theory of Interpersonal Behaviour and the Norm-Activation Model (Schwanen*, et al.*, 2012). Although, other models have also been used, including Stern's Attitude-Behaviour-Context and Value-Belief-Norm models, the Motivation Opportunity Ability model and others, for example Stern (2000), Gatersleben and Appleton (2007), Schwanen*, et al.* (2012), Klöckner and Blöbaum (2010), Thøgersen (2009).

The importance of understanding behaviour theory when trying to change individuals' travel choices is increasingly being recognised in both research and policy development (Heinen*, et al.*, 2010; Schwanen*, et al.*, 2012), as "transport academics now agree that at least some level of behaviour change is unavoidable if carbon emissions from transport are to be reduced significantly" (Schwanen*, et al.*, 2012, p. 522).

Research that has assessed the role of attitude (included in both the Theory of Planned Behaviour, the Theory of Interpersonal Behaviour and others) in the choice to cycle for transport has found it to be important. A study by Dill and Voros (2007) found that, for most people, attitudes towards car use are usually more positive than those towards cycling and that a positive attitude towards cycling increased the likelihood of commuting by bicycle. Gatersleben and Appleton (2007) found that people considering cycling have a more positive attitude towards cycling than those who are not (56%: 34%). They also identified that the more favourably individuals evaluated the outcomes of cycling the more likely they are to cycle for transport. Evaluation of outcomes is identified as an antecedent to attitude in a number of the previously mentioned behaviour theories. In support of this, Stinson and Bhat (2004) found that a negative evaluation of car use outcomes leads to an increased likelihood of cycling for transport.

Subjective, personal and social norms have also, mostly, been found to influence an individual's behaviour when it comes to travel mode choice (Bamberg*, et al.*, 2007). For example, Hunecke *et al.* (2001) identified that strong environmental beliefs correlate with increased public transport use. The authors suggest the same may be true for walking and cycling. de Bruijn *et al.* (2005) found that cyclists tend to perceive more positive social norms around cycling than non-cyclists. Similarly, de Geus (2008) found that cyclists perceive more social support for cycling than non-cyclists. Also, Dill and Voros (2007) found that individuals were more likely to cycle if their co-workers cycled. In contrast, early research by Bamberg and Schmidt on the Theory of Planned Behaviour found no link between social norms and transport behaviour (Bamberg & Schmidt, 1994; in Heinen*, et al.*, 2010). Interestingly, recent theses undertaken in the Wellington Region by Lake (2010) and Morley (2011) both found evidence that social norms do not significantly affect pro-environmental behaviour. This is in line with the idea that social norms differ between social groups (Jackson, 2005; Ostrom, 2000).

Contextual factors and the constraints these place on choices of action are clearly very important when considering what influences behaviour to travel car, bicycle or foot. As Schwanen *et al.* state "in many attitude theory-based empirical studies travel behaviour is considered the outcome of both choice and constraints." (Schwanen*, et al.*, 2012, p. 523).

The perceptions of these barriers are also very important (Kingham*, et al.*, 2011). Studies from Gatersleben and Appleton (2007) and de Geus (2008) have shown that individuals who do not commute by bicycle are likely to perceive more barriers to cycling than those who do. Accordingly, Bamberg and Schmidt (1994) found that cyclists perceive more possibilities for cycling than non-cyclists. According to Ajzen (1991), if the perception of these barriers matches the reality, then behavioural intention will lead to that behaviour.

Habits are increasingly being seen as highly important in explaining travel behaviour (Bamberg & Schmidt, 2003; de Bruijn & Gardner, 2011; Schwanen*, et al.*, 2012; Verplanken*, et al.*, 1997; Verplanken*, et al.*, 2008). Everyday choices are not purely controlled, conscious processes, as set out in the Theory of Planed Behaviour and similar attitude theories, but are heavily influenced by habits (Bamberg & Schmidt, 2003; Schwanen*, et al.*, 2012).

A study by Bamberg and Schmidt (2003) found that people do not consider all factors when deciding on travel mode choice. In conducting this, they compared the Theory of Planned Behaviour, the Theory of Interpersonal Behaviour and the Norm-Activation Theory to find that the Theory of Planned Behaviour was the most easily applied model to explain travel mode choice, but was greatly improved by including 'role beliefs' (a part of social factors) and habits from the Theory of Interpersonal Behaviour. This is in support of the findings of Ouelette and Wood (1998), where the frequency of past behaviour was identified as a measure of habit and its use significantly improved the predictive power of attitudes and intention.

Other studies have also looked at the role of habit in travel behaviour. Verplanken *et al.* (1997; 2008) identified that being in the habit of using other forms of transport than cycling reduces the likelihood of cycling.

The practice of cycling for transport can also become a habitual behaviour. This was shown by the work of Stinson and Bhat (2004), where cycling to work over a long period of time was shown to lead to increased frequencies of trips by bicycle and therefore a stronger cycling habit. Also, cycling during free time was shown to be associated with a higher frequency of utilitarian bicycle trips. Similarly, Dill and Voros (2007) concluded that childhood cycling increases the likelihood of cycling as an adult.

Research suggests that trying other modes can break travel habits. For example, Rose and Marfurt (2007) concluded that trying out the commute by bicycle is sometimes enough to break commuting habits and change mode choice. Bamberg, Ajzen *et al.* (2003) showed that providing free bus tickets encouraged people to change their usual mode of transport and thus weaken their mode choice habits. Similar research, however, has found that this alone is not enough to break an engrained habit (de Witte*, et al.*, 2006).

Having an intention to change one's travel mode can be enough to break a habit (Bamberg, 2002), but only if that habit is weakly engrained in the first instance (Darnton*, et al.*, 2011; Gardner, 2009). However, interventions to change the costs and benefits associated with a habitual activity are more effective ways of breaking habits

(Fujii & Kitamura, 2003; Thøgersen, 2009). Furthermore, major changes in an individual's life situation (such as moving house) increase this effectiveness (Verplanken, *et al.*, 2008).

2.3 Summary

As can be seen from this brief survey of the relevant theory, human behaviour is complex. There are many influences on behaviour and much variability between individuals and social groups. It is important to understand the difficulties in accounting for these variations in the models and this is why so many models have been discussed in this section.

However, from the studies reviewed a number of points relevant to transport behaviour can be taken. Attitude plays a key role in behaviour when contextual factors are not too constrictive and limiting (Stern, 2000). Intention is closely correlated to behaviour if contextual factors are realistically perceived by the individual (Ajzen, 1991). Habits moderate the relationship between intention and behaviour. Social factors, including the individual's beliefs about their role in society and social norms, as well as personal norms, often have a measurable effect on intention and behaviour, but this influence is moderated by contextual factors (de Bruijn, *et al.*, 2005; Dill & Voros, 2007; Hunecke, *et al.*, 2001; Jackson, 2005; Stern, 2000). Contextual factors have a large influence on behaviour, as do social norms, past behaviours and habits. As shown, there are many models of how these factors influence each other and how they combine to influence behaviour. Furthermore, there is clearly not full agreement in the literature.

Through comparing some of the main behaviour models, Bamberg and Schmidt (2003) found that, out of the Theory of Planned Behaviour, the Theory of Interpersonal Behaviour and the Norm-Activation Theory, the Theory of Interpersonal Behaviour was able to explain more trips than the other two models. However, attitude, subjective norms and PBC seemed to mediate the effects of all of the other factors in the Theory of Interpersonal Behaviour on intention, except for role beliefs and habit. More recent studies have also shown good explanation of behaviour by using the Theory of Planned Behaviour with habit factored in as a moderator of behaviour (de Bruijn & Gardner, 2011; de Bruijn & Rhodes, 2011).

2.4 Application to This Research

With this in mind, and taking into account the ease of understanding and applicability to empirical research, it would appear that the most appropriate model to use for this research is one based on the Theory of Planned Behaviour with the inclusion of habits as a direct moderator of behaviour alongside intention. It should also include the broader category of a 'social factor' (Bamberg & Schmidt, 2003) in place of the more limited 'subjective norm'.

There are clearly contextual issues that are outside the scope of PBC. The context within which an individual makes decisions will not act in isolation on their behaviour, but will also logically act through all of the behavioural antecedents. It becomes important to include a contextual factor in these models that acts as a filter through which certain behaviour may or may not be possible. In this case, rather than context acting between intention and behaviour (as used by Ölander and Thøgersen (1995) in the Motivation-Opportunity-Ability model and Triandis (1977) in the Theory of Interpersonal Behaviour model), it could be seen as the 'container' in which the model acts.

It also seems logical that such a model would not be limited to one-off, linear action. This means that the resultant behaviour would influence related future behaviour, through a feedback loop acting on habit, attitude via outcome beliefs and evaluation, and PBC. This then closely resembles the Theory of Planned Behaviour, but with a context 'container', feedback loops and habits added, and subjective norms replaced with a new Social Factor that combines Ajzen's subjective norms with Triandis' social factors.

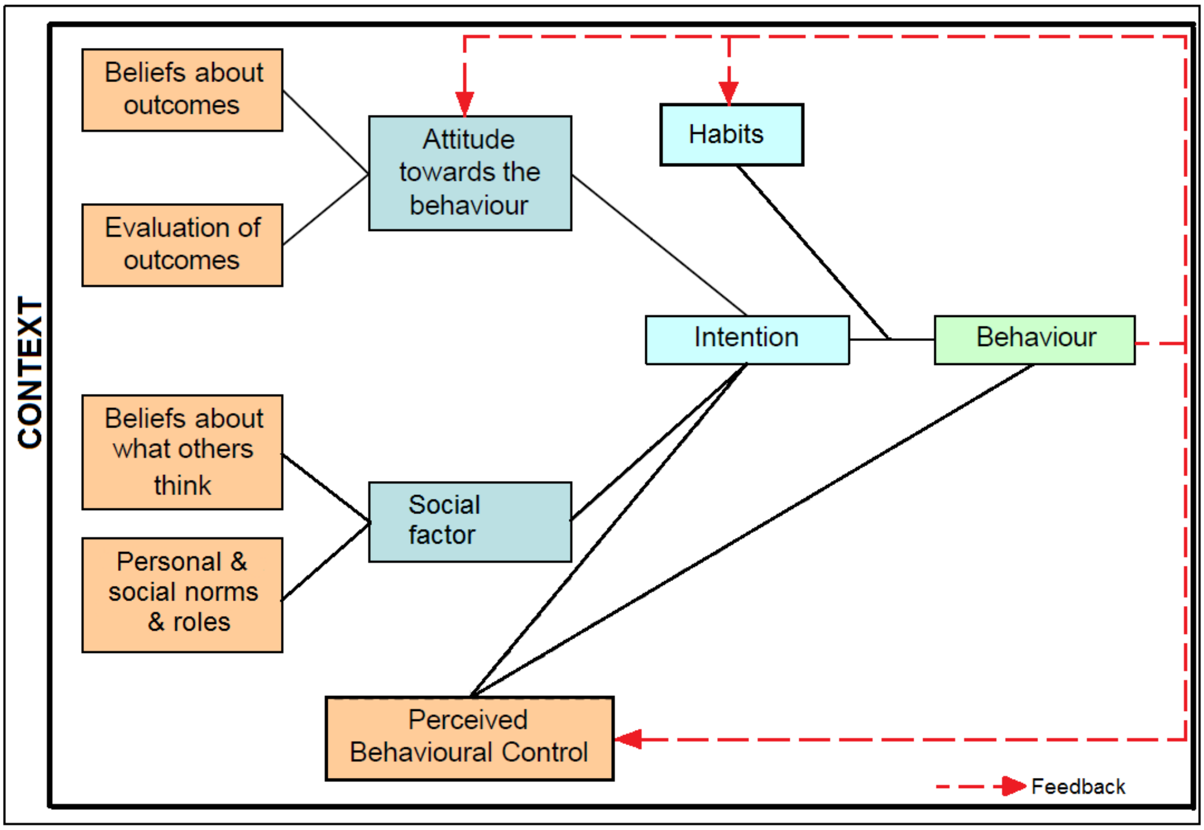

Figure 6: Adjusted behaviour theory proposed for commuter cycling behaviour (Diagram adapted from Jackson (2005, p. 49), model adapted from the work of Ajzen (1991), Triandis (1977) and others as discussed)

The model shown in Figure 6 provides the conceptual framework for this research project and will be used to address the aim of this study.

2.5 Research Questions

As stated in Chapter 1, the aim of this study is to determine whether recreational cyclists are more amenable to commuting by bicycle than non-cyclists in the Wellington Region. With the literature discussed in this chapter in mind, this aim has been broken down into a number of research questions to be answered. These are:

1. How do socio-economic and demographic characteristics vary between non-cyclist, recreational cyclist and commuter cyclist groups in the survey sample?

2. Can the commuter cycling behaviour model, adapted from the literature, explain the choice to commute by bicycle?

3. How do the latent variables identified in the model differ between the three groups?

4. Why do people cycle for transport and recreation and are these reasons similar?

5. For non-cyclists and recreational cyclists, what are the barriers to commuting by bicycle, how do these differ and how can they be overcome?

The purpose of research question 1 is to see if any interesting patterns or differences arise between the three sub-groups, as well as to identify whether the sample follows trends established in the literature. Research question 2 aims to establish whether the theoretical model that has been chosen to examine the choice to commute by bicycle is actually applicable to this behaviour, in the study sample. Research question 3 applies the proposed behaviour theory to identify whether sampled recreational cyclists are more amenable to commuting by bicycle than non-cyclists, as identified by their behavioural antecedent variables. Research question 4 explores the similarities in motivations between the two forms of cycling to provide insight into the likelihood of moving from recreational cycling into commuter cycling. Lastly, research question 5 investigates whether the barriers and opportunities for recreational cyclists to take up commuter cycling are more easily overcome and provided, respectively, than for non-cyclists.

How this study will answer the research questions and address the aim is explained in the next chapter, Chapter 3: Methods.

Chapter 3: Methods

3.1 Approach

This research is framed from a pragmatic philosophical viewpoint. As such, the focus of this study is primarily on the outcomes or consequences of the research. The specific research questions and how best to answer these are the key aspects taken into consideration, rather than starting with a particular method in mind. The methods of choice for a pragmatic study are those that "work" and, as such, this study employs a mixed methods design (Creswell & Plano Clark, 2011).

In order to determine whether recreational cyclists are more amenable to commuting by bicycle than non-cyclists in the Wellington Region it is important to first identify the theoretical lens that this question is to be viewed through and establish how this lens will be used to discuss the answers to this question (Creswell & Plano Clark, 2011). The theory that was used in this study has been outlined in Chapter 2. Using the modified Theory of Planned Behaviour set out earlier, this study assessed the differences in the antecedent factors of commuter cycling behaviour between the participants. Specifically, participants were split into three cycling groups - Commuter Cyclists, Recreational Cyclists and Non Cyclists – and were compared to each other in terms of their attitude towards commuter cycling, their perceptions of and beliefs about social norms on commuter cycling, their perceived behavioural control towards and their intention to commute by bicycle in the near future, and their habits of commuting by car. The differences found among the study participants are then discussed, in relation to behaviour change theories, in the final chapter of this thesis, to explore what they might mean for commuter cycling promotion policies and the support for recreational cycling in Wellington.

As stated above, this study employs a mixed methods design. It takes an explanatory and convergent approach by collecting both quantitative and qualitative data simultaneously from the same sample. The quantitative data are used to explore the proposed behaviour model and how this fits the observed behaviours, preferences and opinions of the participants. The qualitative data are used to enhance the quantitative data and enrich the study by providing a deeper insight into the participants' expressed assessment of barriers and motivations to cycle for commuter transport and recreation. This also gives the participant the opportunity to share views and opinions that may not otherwise be captured in a quantitative framework.

This study has been granted ethics approval by the Victoria University Human Ethics Committee. The approval letter can be found at Appendix A.

3.2 Data Collection and Analysis Process

The data for this study were collected through an online survey. This data collection method was chosen because it provided a fast, economic and straightforward way of reaching a large population. It does, however, come with a number of limitations and biases. One significant bias is access to the survey. While New Zealand has a high level of internet access (International Telecommunication Union, 2013) and the Wellington Region is above the national average (Statistics New Zealand, 2006b), especially when access at work is taken into account, this is not necessarily spread evenly across the population (Statistics New Zealand, 2004). Online surveys also tend to select for people who spend significant amounts of time at a computer with internet access and, as with most surveys, generally attract people with a pre-existing interest (whether positive or negative) in the research topic. Internet surveys do have the advantage of being flexible about when participants can respond, as so may be relatively attractive in this respect (Evans & Mathur, 2005). However, some limitations of paper surveys also apply, such as biases in the wording of questions, language, information availability and answer options. These limitations can make it very difficult to select a representative sample from the population being studied. Despite these limitations it was decided that an online survey was still the best option for this study given the time, money and labour constraints. To counteract these limitations the survey and recruitment email were carefully created and tested, and a large sample size was sought (Hensher*, et al.*, 2005; Kroes & Sheldon, 1988).

3.2.1 Survey Design

When designing this project a range of qualitative data collection tools were examined, including interviews, focus groups and survey questions. Given the data needs of this study, namely to collect the views of a wide range of people who work in the

Wellington Region, and to be able link the qualitative information collected with the quantitative data on, for example, cycling behaviour, the best option was to combine the qualitative and quantitative data collection into the same online survey.

Focus groups in particular were considered, but were discounted for a number of reasons. Firstly, the online survey had a large sample size (n= 778) and included open-ended questions that covered the main topics that would have been discussed in the focus groups. This meant that the value added to the study of a discussion with a small number of people (the initial target focus group sizes were 6 to 8 participants per group, with three focus groups run in total) would be quite small, when the average number of responses to the qualitative survey questions on the same topics was n= 553. Secondly, there are known limitations to focus groups, such as disproportionately representing the views of people with the 'loudest voice' (both certain individuals within the group and also the individuals who are willing to commit the time and effort to a focus group that may have a vested interest in the topic); the significant biases that can be introduced into the focus group process by the researcher (despite their best efforts to remain neutral); and the significant time required to organise, run and analyse the data (Smithson, 2000). Overall, the benefits of holding focus groups would not outweigh the costs and the study would benefit more from a more careful scrutiny of the survey data rather than collecting data through another tool.

A copy of the online survey can be found in Appendix B. The online survey company Qualtrics was used to host the survey as Victoria University of Wellington has a licence agreement with Qualtrics for this service. The survey includes socio-demographic questions, questions to allow the grouping of participants based on commuter transport options and a series of behavioural questions. These behavioural questions have been adapted from a 'Transport and Lifestyle Survey' from the New Zealand Centre for Sustainable Cities (NZ Centre for Sustainable Cities, 2011), as well as two similar transport-related surveys in the recent literature (Bamberg*, et al.*, 2007; Morley, 2011). These questions have been designed to provide insight into the participants' antecedent behaviour variables, so consisted of a number of questions that assessed various aspects of attitude and perceived social norms of commuter cycling, intention to commute by bicycle, perceived behavioural control (PBC), cycling behaviour and car driving habits. Table 1 shows which questions (observed variables) are associated with each of the behavioural, and behavioural-antecedent constructs (latent variables).

Table 1: Survey questions relating to latent behavioural and behavioural-antecedent variables.

Construct (Latent Variable)	Survey Question (Observed Variable)[3]
Attitude	16. I like to, or would like to cycle to work or study
	17. In your opinion, cycling as a means of transport is: (1). Good/Bad (2). Enjoyable/Unpleasant (3). Sensible/Not Sensible (4). Convenient/Inconvenient (5). Realistic/Unrealistic (6). Safe/Unsafe
Social Factors	18. (1). Most people like me commute by bicycle. (2). Most people who are important to me commute by bicycle. (3). Most people who are important to me would approve of me commuting by bicycle. (4). Regardless of what other people do, I feel motivated to commute by bicycle because of my own values.
Perceived Behavioural Control (PBC)	18. (5). It would be impossible for me to commute by bicycle. (6). I am sure that in the next few days I can cycle to work or study. (7). It is mostly up to me whether I use a bicycle rather than a car to get to work or study. (8). I do not feel capable of cycling to work or study.
Intention	22. How likely is it that you will commute by bicycle in the next few weeks? (Or after returning from the Christmas break)
Driving Habit	21. (1). I often drive to get to work or study. (2). It would make me feel strange if I did not drive to work or study. (3). Driving to work or study belongs to my daily or weekly routine.
Commuter Cycling Behaviour	6. Do you have access to a bike that is suitable for commuting?
	11. On average how many days do you commute by bicycle?
	19. /20. How do you usually get to work/study?
	21. (4). Cycling to work or study is something that is typically me. (5). Cycling to work or study belongs to my daily or weekly routine. (6). I have not cycled to work or study for a long time.

[3] The full survey can be found in Appendix B, including the specific response range for each question.

3.2.2 Recruitment

Survey recruitment was done via the snowball method, where an email containing information about the study and a link to the survey was sent to a number of individuals and organisations in the Wellington Region with a request for recipients to forward the email on to anyone that they believed may be interested in completing the survey. Participation in the survey was limited to those who live in the Wellington Region, commute for either work or study and are 18 or older. While this recruitment technique can bias responses by allowing self-selection and over-representation of the social groups that the originally-recruited participants are in, it does allow the survey to reach a large number of people quickly and still allows theoretical inferences to be made based on the sample (Fricker, 2008). The breadth of responses is reported in Chapter 4. Attempts were made to limit these biases by sending out the recruitment email to a wide range of organisations in the area, including private companies, many government departments, universities, community centres, councils and hospitals. Participation was also encouraged by the offer of entry in a prize draw for a $100 voucher on completion of the survey to attract people who would otherwise have no interest in completing a transport survey (entry to this draw was kept separate from the survey responses to ensure the anonymity of the survey data in accordance with ethics approval).

The survey was first launched on 17 December 2012 and another round of recruitment emails were sent out in early February 2013, at the end of the usual summer holiday period in Wellington. The survey was finally closed on 30 April 2013 with a total of 778 complete responses and a completion rate of 93.5%. As recruitment was via the snowball method and ethics approval required responses to be anonymous, the recruitment emails were not tracked. This means that it is not possible to know how many people received the recruitment email; nor is it possible to calculate a response rate for the survey. Details of the sample size and characteristics are fully discussed in the results chapter, Chapter 4.

Two months before the survey was closed it was noticed that the responses from Māori and Pasifika people were under-represented. During the final two months individual emails were sent to a number of Māori and Pasifika groups in the region to encourage further participation. However, this did not lead to a significant increase in responses. It was therefore decided that ethnicity was significantly unrepresentative of the wider population and as such this variable was not useful for statistical tests.

Once the survey was closed the responses were reviewed and all incomplete responses were removed (n= 54). The data were also checked for duplicate cases using the demographic information and IP address. No duplicates were found.

3.2.3 Data Processing

Respondents were classified as Non Cyclists, Recreational Cyclists and Commuter Cyclists based on their answers to questions 11 and 13. Table 2 shows the responses to these questions that correspond to each group.

Table 2: Cycling group classification criteria

Cycling group into which respondent classified	Question 11: On average how many days do you commute by bicycle? 1. Never 2. Less than 1 per month 3. 1-3 per month 4. 1-2 per week 5. 3+ per week	Question 13: On average how many times do you cycle for recreation (any cycling not for transport)? 1. Never 2. Less than 1 per month 3. 1-3 per month 4. 1-2 per week 5. 3+ per week
Non Cyclist	Less than once per month (option 1 or 2)	Less than once per month (option 1 or 2)
Recreational Cyclist	Frequency same or less than answer to question 13	Once per month or more (option 3,4 or 5)
Commuter Cyclist	Once per month or more (option 3,4 or 5)	Freq. less than answer to question 11

For example, if a respondent commuted once per week, and cycled for recreation once per month, he/she would be classified as a commuter cyclist; conversely, if a respondent commuted once per month, but also cycled for recreation once per month, he/she would be counted as a recreational cyclist.

Next, Likert scale questions were recoded, where necessary, to ensure that for all questions, except those on driving habits, a score of 1 indicated a negative view towards cycling, 4 indicated a neutral view and 7 a positive view. For the driving habit questions 7 indicated a strong driving habit and 1 indicated a weak driving habit. The questions that were recoded were 16 (1), 17 (1-6), 18 (1-4, 6-8) and 21 (1-5). Other questions that were recoded for analysis were 6, 19 and 20.

Once this was complete, missing values were addressed. As there are multiple ways to handle missing values and there is not one clearly preferred method (Byrne, 2010), it was decided to run statistical tests on the data after it had been treated with three common missing values techniques to see if these would result in different statistical outcomes. The techniques tested were listwise deletion, where all data from cases with missing values were deleted; mean replacement, where missing values were replaced by the mean response to that question; and neutral replacement, where missing values were replaced by a neutral response (a '4' on the 7-point Likert scale that was used for all Likert scale questions). These techniques resulted in similar statistical outcomes, a summary of which can be found in Appendix C.

During the survey, participants were instructed to leave answers blank if they did not know the answer to a question. Therefore, it could be argued that a 'don't know' response to a question on opinions and feelings towards a mode of transport is the equivalent of being neutral. Because of this, and because the different missing values treatments did not significantly alter the results, it was decided that replacing missing values with a neutral response ('4') for the Likert scale questions was the most logical option. For non-Likert scale questions that were analysed quantitatively, values were deleted pairwise when missing values occurred (pairwise deletion means the removal of values relating to the specific analysis when one or more of the values are missing in a case (Byrne, 2010)).

Data preparation was performed in Microsoft Excel and all statistical analyses were carried out in IBM SPSS, with the exception of the confirmatory factor analysis and the structural equation modelling which were performed in the SPSS add-on programme Amos.

3.2.4 Statistical Analysis

The sample as a whole was initially analysed to identify which type of people made up the sample and whether the sample was representative of the Wellington Region. Frequency charts of age, gender, income, education and ethnicity of the sample were compared to those for the region from the 2006 Census, obtained from Statistics New Zealand (Statistics New Zealand, 2006b).

Next, the differences in the socio-economic and demographic characteristics of the three cycling groups (Non Cyclists, Recreational Cyclists and Commuter Cyclists) were assessed. This addressed Research Question 1 and utilised χ^2 tests once again, with standardised residual post-hoc analysis to identify the source of specific relationships.

Factor Analysis

Factor analysis was performed to ensure that the responses to the behavioural and behavioural-antecedent questions could be combined to form latent variables. Confirmatory and exploratory factor analyses identified which questions were likely to be assessing similar aspects of behaviour and behavioural antecedents, and could therefore be combined to form a composite Likert variable. The reliabilities of these relationships were then confirmed with Cronbach's α tests for each potential composite variable. Once the best combination of questions was determined, composite variables for intention, social perceptions, PBC, attitude and driving habit were created by averaging the responses to the relevant questions for each case. This created Likert variables with continuous scales from 1 to 7.

For the Commuter Cycling Behaviour latent variable, two different constructs were created. The first construct created was a continuous Likert variable with a scale from 1 to 7, as with the previously mentioned constructs. This was created by, firstly adding together the scores of questions 6, 11 and 19/20 (after recoding), then averaging this score with the scores to questions 21(4) and 21(5). This combination of questions was identified using exploratory factor analysis and Cronbach's α.

The distribution of this composite behavioural variable, along with the distributions of the other constructs, was then examined for normality. The full results of this can be found in Appendix D. The normality test for the behaviour construct exhibited significant skewness and kurtosis, showing that this variable did not have a normal distribution. As this variable was to be used as the outcome variable in the regression analysis, a non-normal distribution may skew the results and lead to unreliable conclusions (Byrne, 2010; Golob, 2003). It was therefore decided to convert the behaviour variable into a binary, true/false, variable and use this in a logistic regression. As a comparison, structural equation modelling (using the scale behaviour variable) is also undertaken. To create the binary behavioural variable, scores in the composite Likert behaviour variable of more than '4' were classed as true for commuter cycling behaviour and given a '1', and those of '4' or less were classed as false and given a '0' in the binary behaviour variable.

Structural Equation Modelling

To discover whether the proposed theoretical model was applicable to commuter cycling behaviour and whether the data collected showed any links between the hypothesised behavioural antecedents and observed commuter cycling behaviour (Research Question 2), structural equation modelling (SEM) on the sample as a whole was performed. SEM is a statistical technique that analyses, through a series of regression equations, how well observed data fit a proposed theoretical model. It has the advantage of being able to use both directly measured data and latent variables (measured indirectly) to confirm a hypothesised model and infer causal relationships between variables. SEM can also correct for measurement errors, to a certain extent, unlike other regression methods. It does, however, require multivariate normal distribution and no missing data (Byrne, 2010; Schumacker & Lomax, 2004). Additionally, when dealing with large sample sizes a number of the fit measures, such as χ^2, tend to give false results (Schumacker & Lomax, 2004).

SEM was chosen for this study as it is a powerful tool for assessing the applicability of the proposed behaviour model to commuter cycling and is commonly used in pro-environmental behaviour and transport choice studies (Bamberg*, et al.*, 2007; Golob, 2003; Morley, 2011). The ability to effectively test the hypothesis that the modified Theory of Planned Behaviour fits commuter cycling behaviour and to infer the causal impact of particular attitudes, social perceptions, habits, etc. on transport choice makes SEM a sensible choice for addressing the aim of this study and answering the research question 2. Due to the issues with data normality and the difficulty of incorporating contextual factors in the structural equation model, regression analysis was also performed on the data. The use of both statistical methodologies ensures that the applicability of the proposed theory to this study has been thoroughly tested, and that any conclusions drawn on whether or how recreational cycling might lead to commuter cycling based on this theory, can be drawn with confidence and statistical support.

The proposed theoretical model, set out in Chapter 2, was adapted for use with IBM SPSS Amos and is presented in Chapter 4. Feedback loops and the contextual 'container' of the theoretical model could not be effectively modelled. Contextual elements were included in the binary regression and also considered in the qualitative analysis. Feedback loops would require a longitudinal examination of individual commuter cycling behaviour, which was outside the scope of this project. As such, feedback loops have not been accounted for in this analysis, but are still an important theoretical aspect of individual behaviour, as discussed in Chapter 2.

Although studies have shown that SEM is reasonably robust against violations of normality in the data, it was decided that it would be best to use bootstrapping to attempt to correct for distribution violations (Schermelleh-Engel*, et al.*, 2003). Bootstrapping involves resampling the data based on 'random sampling with replacement' to create a distribution of standard errors that can then be used to estimate the standard errors for the structural equation as a whole, removing any reliance on assumptions of normal distribution (Diaconis & Efron, 1983). The IBM SPSS Amos user guide states that bootstrapping should be used in SEM when dealing with non-parametric data (Arbuckle, 2012).

The goodness-of-fit of the model was analysed using a range of measures. Table 3 shows which measures were used and the corresponding cut-off values of these measures for rejection or otherwise of the model.

Table 3: Goodness-of-fit measures used to assess model fit in SEM[4].

Measure	Estimated value should be …
GFI	> 0.95
CFI	> 0.9 (> 0.95, very good fit)
TLI	> 0.95
RMSEA	≤ 0.08
χ^2/DF	<2

χ^2 results (last row of Table 3) were not, however, considered when determining model fit as this measure is very sensitive to large sample sizes (Schumacker & Lomax, 2004) and violations of the assumption of normality (Golob, 2003).

It is generally accepted that a range of goodness-of-fit measures should be reported in SEM (Byrne, 2010; Hu & Bentler, 1999; Schermelleh-Engel*, et al.*, 2003). Even if the model passes these goodness-of-fit tests, the measures do not confirm that the model is "correct", as it is possible that a different model may fit the data better (Golob, 2003). Therefore, in the face of conflicting goodness-of-fit measures a judgment call must be made, based on the sample size, complexity of the model and normality of the data, as to whether the model is rejected or not (Byrne, 2010; Hu & Bentler, 1999; Morley, 2011; Schermelleh-Engel*, et al.*, 2003).

Once the statistical fit of the theoretical model to the observed data was established, the correlation coefficients among the model parameters were assessed, firstly to ensure that they were logical and made sense in the context of the literature, and secondly to see how each behavioural antecedent influenced the outcome behaviour variable and what this might mean for the promotion of commuter cycling.

Binary Logistic Regression

The next step in confirming the applicability of the model to the collected data was to perform regression analysis. This was done for three reasons, the first being to help build robust conclusions about the model fit despite the violations of parametric distribution, discussed above. In other words, the binary logistic regression can provide

[4] Cut-off values indicate the limits of a good fit of the model to the data. Values outside the ranges given here indicate that the model should be rejected (Gerbing & Anderson, 1993; Hu & Bentler, 1999; Schermelleh-Engel*, et al.*, 2003).

qualified corroboration of the SEM results. Secondly, binary regression takes into account contextual factors, including age, gender, income, education and ethnicity, which may be altering the relationship between the theoretical behavioural antecedents and the observed behaviour. This helps to align the tested behaviour model more effectively with the literature by better illuminating the context within which commuter cycling behaviour occurs. Thirdly, this methodology provides another measure of how well the proposed model fits the data by assessing the accuracy of the model through the predicted versus observed results from the logistic regression.

Binary logistic regression was performed in IBM SPSS with the binary behaviour variable as the outcome variable; intention, attitude, social factors, PBC and driving habit set as covariates; and gender, age, income, education and ethnicity set as confounders.

ANOVA and Tukey HSD

Once the fit of the proposed model was established and the roles of attitude, intention, social perceptions, driving habit and PBC in determining commuter cycling behaviour were verified, it was then possible to analyse whether there was a difference between the three cycling groups, with regard to these behavioural factors, and therefore provide an answer to Research Question 3.

This was assessed using ANOVA, which assesses differences in means between groups. Where a difference was confirmed, post-hoc analysis was performed to see exactly how the three groups differed and to determine whether Recreational Cyclists or Non Cyclists were more closely related to Commuter Cyclists in terms of the attitude, intention, social perceptions and PBC of Commuter Cyclists, and their driving habits.

The test used to do this was Tukey HSD, which compares the means of the variables of interest between the three groups to identify whether the differences between any two of these means are greater than the expected standard errors. When this is the case, it can be concluded that the means are significantly different between the groups (Lane, 2010). The aim of using this test is to identify whether the Recreational Cycling group is significantly different to the Non Cycling group, and whether it is closer to the Commuter Cycling group than the Non Cycling group, with regard to the behavioural antecedent variables. If this is established then it would suggest that Recreational Cyclists view commuter cycling more favourably than Non Cyclists and may, therefore, be more likely to take up commuter cycling, whether on their own or as a result of commuter cycling promotion policies.

3.2.5 Qualitative Analysis

Qualitative analysis was used to address Research Questions 4 and 5. Survey participants were asked four open ended questions to gain a deeper insight into the reasons why they cycled for transport or recreation, the barriers that they feel stop them from cycling to work or place of study and what would encourage them to commute by bicycle more often. The written responses to these questions were reviewed and a list of themes was created. The list of themes can be found in Table 4. This list was developed through reading the responses to gain an understanding of the range of views and opinions present. This was also informed by an understanding of the related literature (on the barriers, motivations, and interventions for utilitarian cycling).

The responses were then given codes that correspond to the previously identified themes. From this thematic coding, the frequency of occurrence of each theme was assessed and compared for the appropriate cycling groups, to identify which themes were most important and most widely represented. This qualitative analysis was performed in Microsoft Excel.

Table 4: Themes used for thematic coding of responses to questions 12, 14, 23 and 24.

<table>
<tr><th>Question</th><th colspan="2">Themes</th></tr>
<tr><td rowspan="4">12. If you do commute by bicycle why do you choose this mode of transport?
14. If you do cycle for recreation, why do you choose to do this?</td><td>Enjoyment</td><td>Health</td></tr>
<tr><td>Social</td><td>Cost</td></tr>
<tr><td>Convenience</td><td>Time</td></tr>
<tr><td colspan="2">Sustainability</td></tr>
<tr><td rowspan="5">23. What are the barriers to you cycling (or cycling more often) to work or study?</td><td>Weather</td><td>Hills</td></tr>
<tr><td>Equipment</td><td>Distance</td></tr>
<tr><td>Danger</td><td>Inexperience</td></tr>
<tr><td>Destination Facilities</td><td>Trip Chaining & Luggage</td></tr>
<tr><td>Otherwise impractical</td><td>None</td></tr>
<tr><td rowspan="4">24. What, if anything, would encourage you to cycle (more regularly) to work or study?</td><td>Road infrastructure</td><td>Cultural Shift</td></tr>
<tr><td>Destination Facilities</td><td>Equipment</td></tr>
<tr><td>Experience</td><td>Public Transport Integration</td></tr>
<tr><td colspan="2">Nothing</td></tr>
</table>

The results from both the quantitative and qualitative analysis were then examined to identify where these two strands of analysis supported each other and where they differed. Bringing together the two strands of research at this stage is designed to broaden and enrich the findings and allow deeper and more insightful conclusions to be drawn. This was done in the discussion chapter of this thesis (Chapter 5).

3.3 Limitations

A number of limitations and assumptions in this study have already been mentioned. Others exist such as the portrayal of cognitive dissonance, or a mismatch between stated intentions and beliefs and actual behaviour, in behavioural surveys (Schwanen, *et al.*, 2012). A full discussion of the limitations, assumptions and short-comings of this research and how these impact on the results and conclusions of the study can be found in the final discussion chapter.

The next chapter presents the results of the quantitative and qualitative analysis. This addresses the findings of each research question in turn.

Chapter 4: Results

This chapter presents the results of this study. Firstly, the characteristics of the survey sample are compared to those of the Wellington regional population. It is shown that the sample is not representative, so any conclusions drawn are applicable only to the study sample. Research question 1 is then addressed by using χ^2 tests of independence to compare the characteristics of the Non Cyclist, Recreational Cyclist and Commuter Cyclist groups. Following this, the creation of latent behavioural antecedent variables is explained and the validity of the proposed model for commuter cycling behaviour is explored using structural equation modelling and binary logistic regression, to address research question 2. The final stage of quantitative analysis uses One-Way Analysis of Variance (ANOVA) to assess the differences between the three cycling groups in terms of commuter cycling behaviour and the behaviour's antecedents to address research question 3. The chapter then moves into qualitative analysis that looks at the stated motivations and barriers to commuter cycling of the three cycling groups, and explores the interventions that participants thought would encourage them to commute by bicycle, thus addressing the final research questions, 4 and 5.

4.1 Survey Sample

As discussed in the Methods section, the online survey used for this study had a completion rate of 93.5% and a total of N=778 viable responses.

4.1.1 Sample Characteristics

Respondents were asked questions regarding their gender, age, income, education, ethnicity and main mode of travel to work. These sample characteristics were compared to the most recent Census data available for the Wellington Region (2006) (Statistics New Zealand, 2006b), as shown respectively in Figures 7-12. These figures demonstrate that the study sample is not representative of the population of the Wellington Region. Figure 7 shows that males are slightly underrepresented in the study sample, while females are slightly overrepresented. Figures 8 to 11 show that the study sample exhibits a strong bias toward those aged between 20 and 59 years (Figure 8), those with incomes higher than $50,000 (Figure 9), those with a tertiary education (Figure 10), and toward people of European ethnicity (Figure 11). Figure 12 shows that the study sample underrepresents those who travel by car to work and over represents those who travel by all other modes.

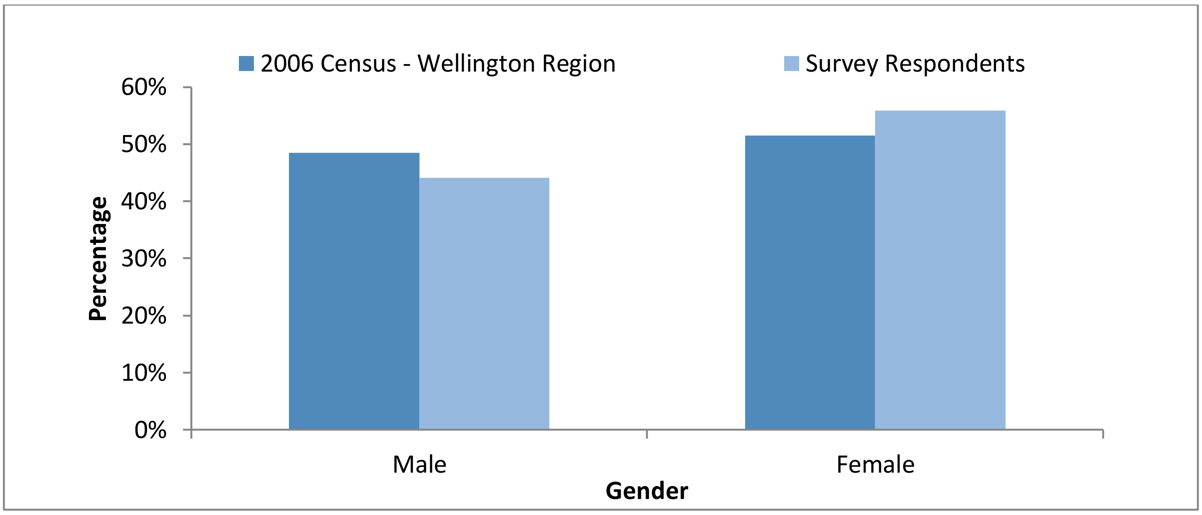

Figure 7: Gender of survey sample (n= 773) compared to 2006 Census data for the Wellington Region

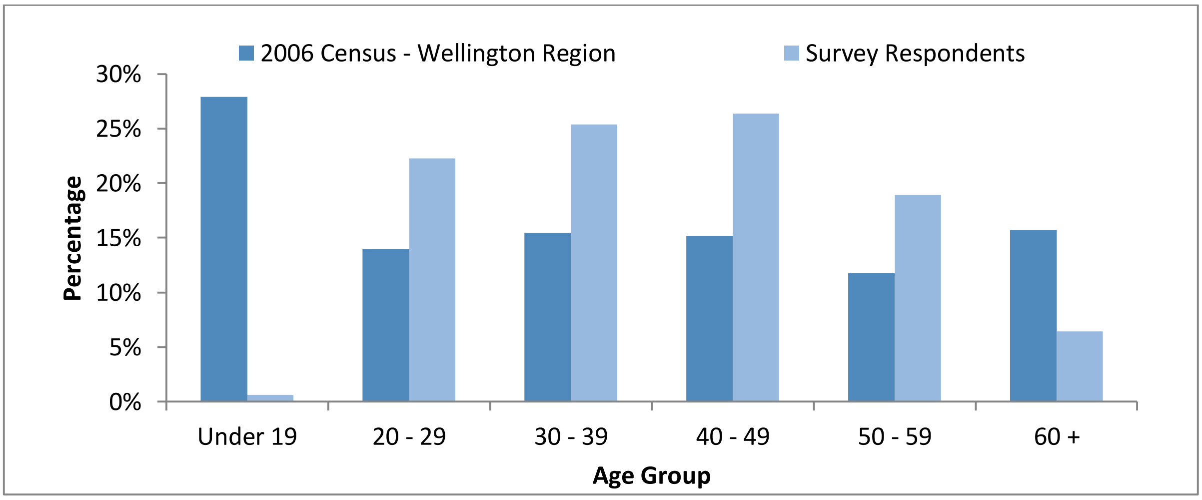

Figure 8: Age of survey sample (n= 777) compared to 2006 Census data for the Wellington Region

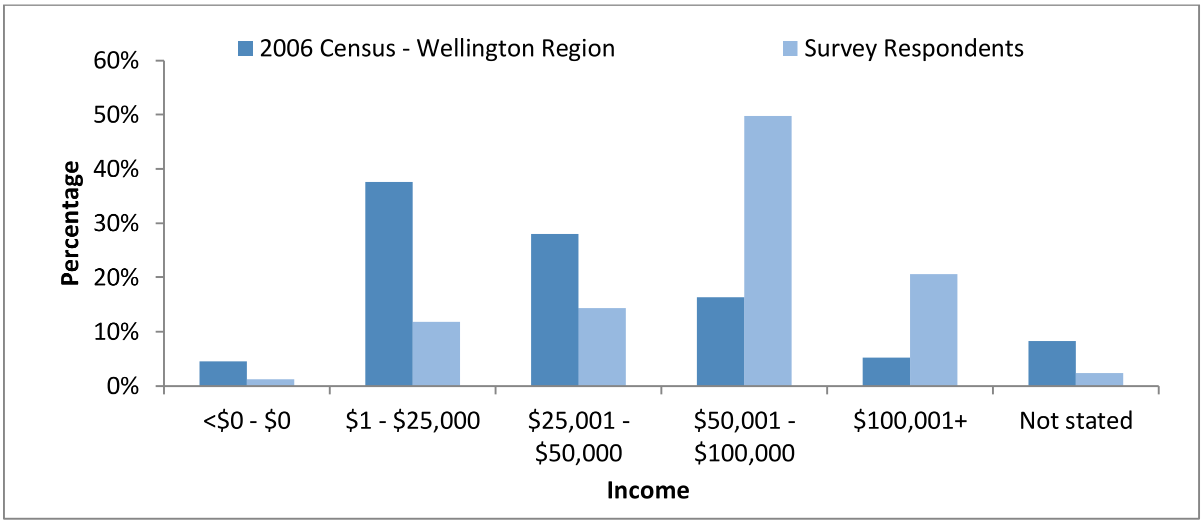

Figure 9: Income of survey sample (n=778) compared to 2006 Census data for the Wellington Region

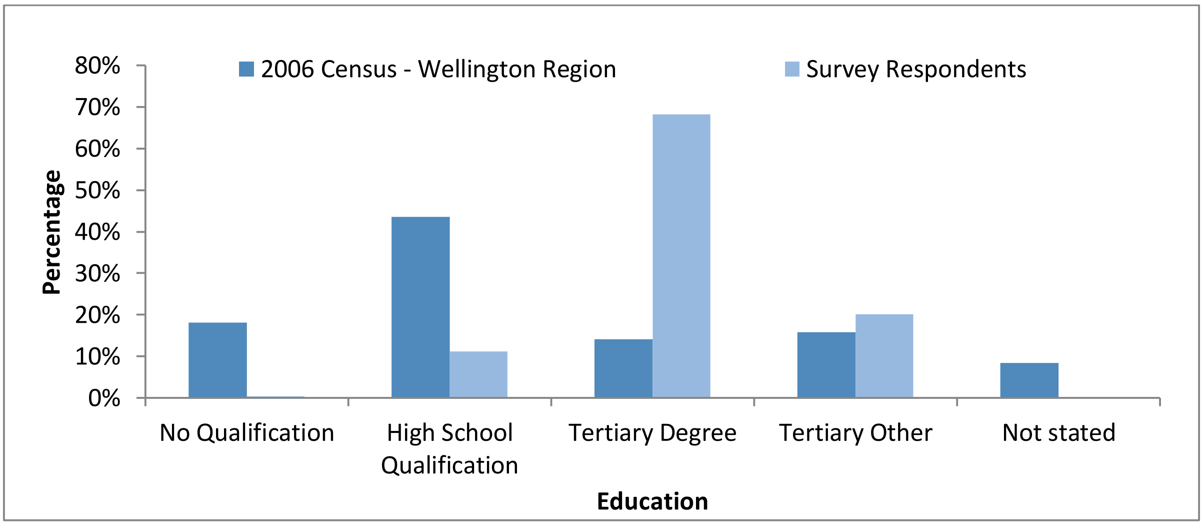

Figure 10: Highest qualification of survey sample (n= 778) compared to 2006 Census data for the Wellington Region

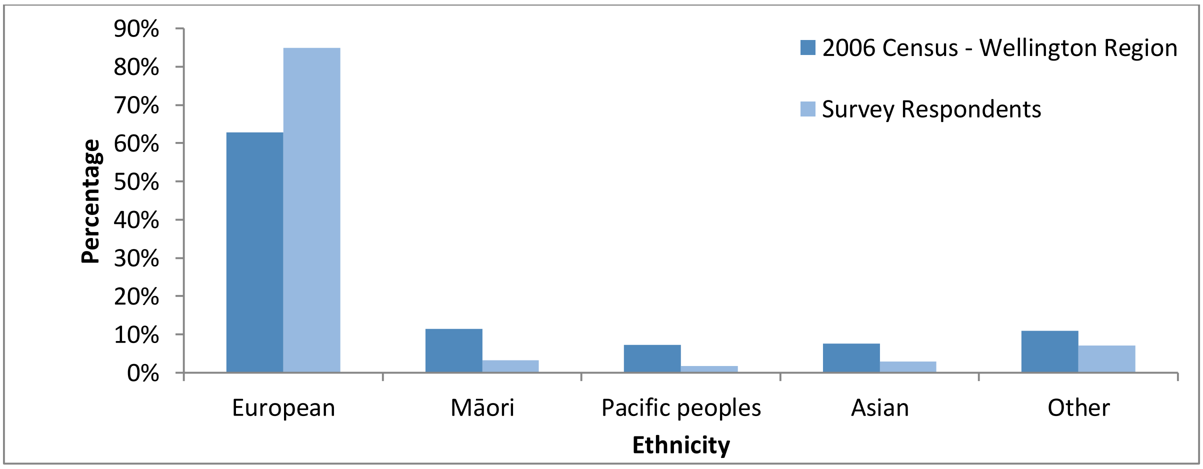

Figure 11: Ethnic groups of the survey sample (n= 769) compared to 2006 Census data for the Wellington Region

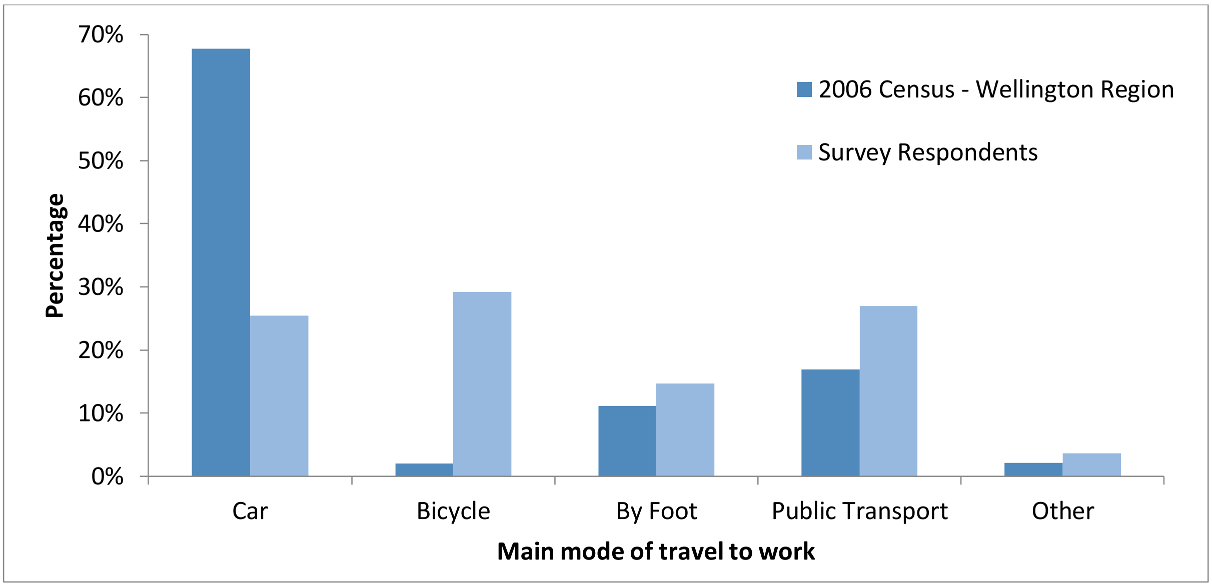

Figure 12: Main mode of travel to work of the survey sample (n= 719) compared to 2006 Census data for the Wellington Region

4.2 Research Question 1

Research question 1 asked 'How do socio-economic and demographic characteristics vary between non-cyclist, recreational cyclist and commuter cyclist groups in the survey sample?' This section outlines the statistical differences between these three groups in terms of gender, age, income and education. Additionally, whether or not respondents cycled to school as children was also examined.

4.2.1 Group formation and group sample sizes

The study respondents were classified as Non Cyclists, Commuter Cyclists, and Recreational Cyclists based on the criteria described in Chapter 3 (Methods). Of the study sample (N= 778), 50.4% were classed as Non Cyclists (n=392), 28.8% were classed as Commuter Cyclists (n=224) and 20.8% were classed as Recreational Cyclists (n=162).

4.2.2 Chi-square tests of independence

Chi-square (χ^2) tests of independence were performed using SPSS to assess whether potential relationships exist (Allen & Bennett, 2012) between cycling group membership and selected demographic variables of: gender, age, income, education and also whether or not respondents had cycled to school when young. Such a test was not performed for ethnicity, as these data were considered too unrepresentative for analysis to be of any particular value. Where significant relationships were found, post hoc analysis (standardised residuals as z-scores) was used to explore the nature of these relationships. See Appendix E for full statistical tables and post hoc analysis of statistically significant relationships.

Gender

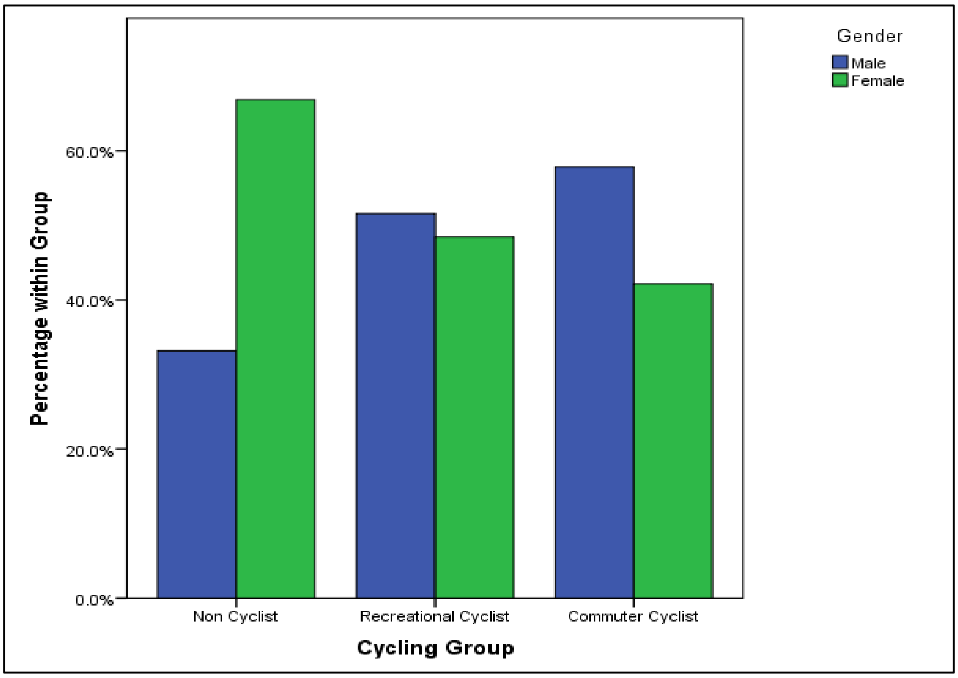

Figure 13: Gender percentages of the three cycling groups. Gender is significantly different between the three groups, χ^2 (2, N= 773) = 39.60, p < .001.

Figure 13 shows the relation between cycle group and gender. This was significant (χ^2 (2, N= 773) = 39.60, $p < 0.001$), with males being underrepresented in the Non Cyclist group (z-score= -3.3) and overrepresented in the Commuter Cyclist group (z-score= 3.1). Females were the opposite, being overrepresented in the Non Cyclist group (z-score= 2.9) and underrepresented in the Commuter Cyclist group (z-score=-2.7). No other categories were major contributors to the χ^2 result.

Age

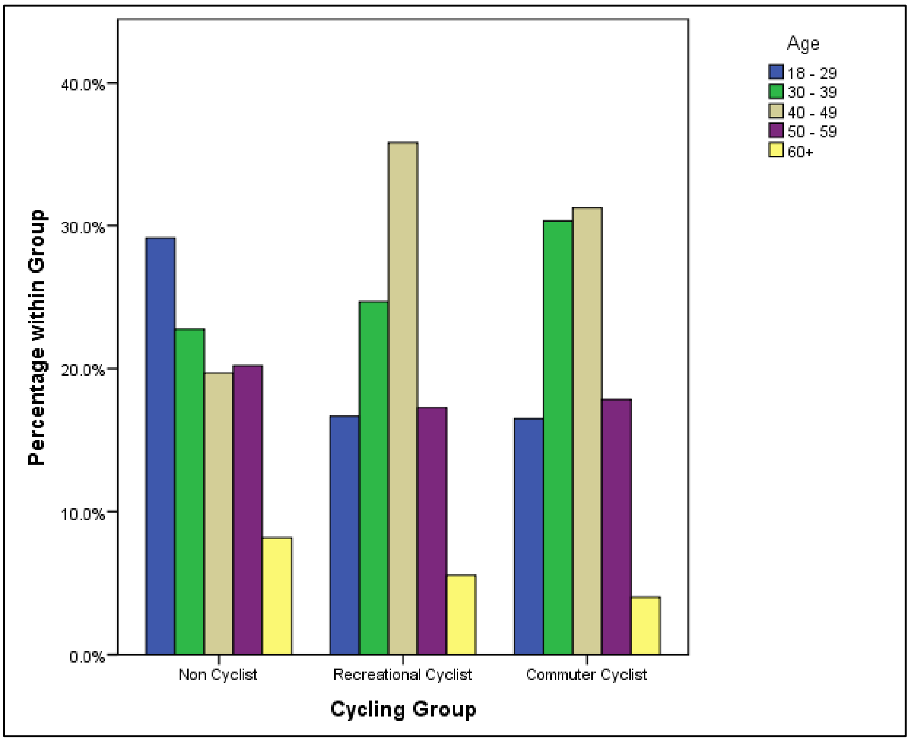

Figure 14: Age of the three cycling groups. Age is significantly different between the groups. χ^2 (8, N= 777) = 35.57, p < .001.

Figure 14 shows the relation between cycle group and age, which was also significant (χ^2 (8, N= 777) = 35.57, p < 0.001). In the Non Cyclist group the 18 to 29 years age group was overrepresented, while the age group 40 to 49 was underrepresented (z-scores= 2.6 and -2.6 respectively). The 40 to 49 years age group was overrepresented in the Recreational Cyclist group (z-score= 2.3). The 18 to 29 years age group was underrepresented in the Commuter Cyclist group (z-score= -2.0).

Income

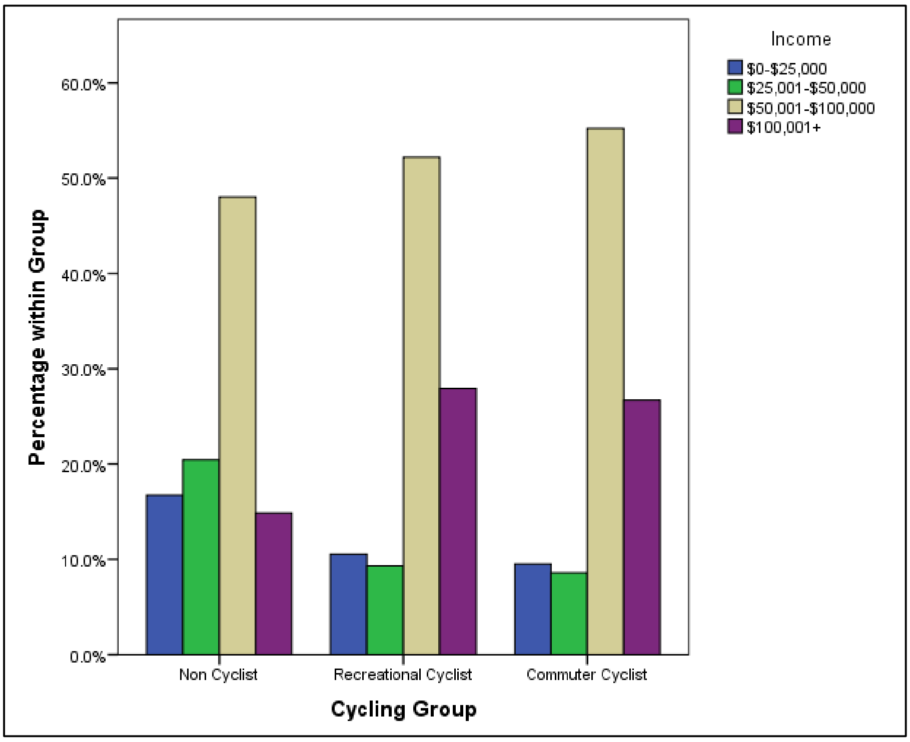

Figure 15: Annual income of the three cycling groups (in NZD). There is a significant difference between the incomes of the three groups. χ^2 (6, N= 759) = 39.18, p < .001.

Figure 15 shows the relation between cycle group and income. What stands out is the association between income and cycling. This is reflected in the statistical significance test, with a significant association (χ^2 (6, N= 759) = 39.18, $p < 0.001$) between those with an income between $25,001 and $50,000 being overrepresented in the Non Cyclist group (z-score= 2.9) and underrepresented in the Commuter Cyclist group (z-score= -2.3). Those with an income of $100,001+ were underrepresented in the Non Cyclist group (z-score= -2.6).

Education

No clear association was found between cycle group and level of education, or more formally, the χ^2 test failed to reject that there is no relationship between cycle group and level of education (χ^2 (4, N= 777) = 8.81, p= 0.066).

Cycling to school when young

The χ^2 test failed to reject that there is no relationship between cycle group and cycling to school as a child (χ^2 (2, N= 775) = 1.45, p= 0.484), with approximately 60% of each group stating that they regularly cycled to school as a child.

4.3 Research Question 2

This section addresses research question 2, which asked 'Can the commuter cycling behaviour model, adapted from the literature, explain the choice to commute by bicycle?'

The construction of the latent behavioural and behavioural-antecedent variables is first confirmed using exploratory and confirmatory factor analysis and Cronbach's α. Structural equation modelling and binary logistic regression are then used to assess the fit of this theoretical model to the observed data.

4.3.1 Factor Analysis

Confirmatory factor analysis was first used to verify the validity of the combined observed variables (survey questions) (Byrne, 2010). Table 5 shows the factor loadings for each survey question from this analysis. The factor loading indicates how strongly the question is associated with its intended latent variable. A factor loading of 0.5 or less indicates that the observed variable is not a valid indicator for the proposed latent variable (Hair*, et al.*, 2006). As Table 5 shows, all of the factor loadings in this confirmatory factor analysis were above 0.5 and therefore all tested observed variables can be considered to be valid indicators for the behavioural and behavioural-antecedent constructs.

The reliability of these constructs was tested using Cronbach's α. A score greater than 0.7 indicates that the construct is reliable and the component variables within this construct are consistent with each other (Hair*, et al.*, 2006). All Cronbach's α scores were above this value, showing that the proposed constructs are appropriate to be used. Additionally, the final column of Table 5 shows that if any observed variables were removed from any of the constructs, the construct's Cronbach's α score decreased. This implies that each survey question strengthens the validity of its respective latent variable.

Table 5: Confirmatory Factor Analysis (Factor Loadings) and Cronbach's α results for the five proposed latent variables

Construct (Latent Variable)	Survey Question* (Observed Variable)	Factor Loading	Cronbach's α	
			Total	Total if question is removed
Attitude	16.	0.75		0.873
	17. (1)	0.69		0.868
	(2)	0.72		0.861
	(3)	0.74	0.888	0.857
	(4)	0.79		0.857
	(5)	0.82		0.855
	(6)	0.58		0.881
Social Factor	18. (1)	0.59		0.699
	(2)	0.52	0.773	0.717
	(3)	0.60		0.716
	(4)	0.88		0.690
Perceived Behavioural Control (PBC)	18. (5)	0.76		0.765
	(6)	0.88	0.841	0.781
	(8)	0.73		0.783
Driving Habit	21. (1)	0.95	0.904	N/A
	(3)	0.87		N/A
Commuter Cycling Behaviour	6.	0.62		
	11.	0.97		0.960**
	19/20.	0.88	0.972	
	21. (4)	0.94		0.967
	(5)	0.97		0.946

* For Complete questions please see Table 1 in Chapter 3 – Methods.

** Analysed as combined scores for questions 6, 11 and 19/20, giving a 'behaviour input' scale variable from 1 (lowest commuter cycling behaviour) to 7 (highest commuter cycling behaviour)

While the confirmatory factor analysis supported the design of the latent variables obtained from the literature, as shown by the factor loadings all being above the cut-off value of 0.5, the goodness of fit statistics for this test were poor. This is most likely due to the large sample size and non-parametric data (Golob, 2003; Schermelleh-Engel*, et al.*, 2003; Schumacker & Lomax, 2004). To explore the construction of the latent variables further, exploratory factor analysis was performed.

Table 6 shows the results of the exploratory factor analysis. Factor loadings of 0.4 and above indicate that the observed variable can be associated with that factor. Higher factor loadings indicate a stronger correlation between the observed variable and latent variable. The highlighted sections of Table 6 show the groups of observed variables for each latent construct.

For each survey question the highest factor loading usually indicates which construct it should be a part of. However, for Q18 (4) and Q18 (6) the highest factor loading did not fall in the desired construct. This suggests that these questions should be associated with Behaviour rather than Social Factor and perceived behavioural control (PBC) respectively. It could be argued that this result could be expected as these latent constructs are proposed to be precursors of behaviour. Therefore, any observed variable that is a measure of one of these precursors would also, logically, be correlated with the resultant Behaviour variable. Additionally, the factor loadings for these questions within their intended constructs are well above the cut-off value. The inclusion of these questions within the corresponding latent variable is also supported by the literature (Bamberg*, et al.*, 2007); therefore these questions have been included within the intended latent variables as indicated in Table 6.

Table 6: Exploratory Factor Analysis Structure Matrix results showing the final combination of survey questions for each construct

Survey Question (Observed Variable)	Construct (Latent Variable)				
	Behaviour	Driving Habit	Attitude	Social Factor	PBC
16.	.645		.673	.510	.563
17. (1)			.763		
(2)	.457		.786		
(3)			.834	.419	
(4)	.534	-.423	.724	.467	.513
(5)	.632	-.411	.708	.534	.626
(6)	.457		.522	.423	.438
18. (1)	.424			.730	
(2)				.724	
(3)			.462	.563	.467
(4)	.736		.646	.649	.590
18. (5)	.604		.418		.836
(6)	.887		.530	.510	.717
(8)	.602				.727
21. (1)		.949			
(3)		.867			
21. (4)	.938		.552	.554	.610
(5)	.973		.527	.518	.617
Behaviour input*	.959		.549	.495	.661

Note. Extraction Method: Principal Axis Factoring.
Rotation Method: Oblimin with Kaiser Normalization. Coefficients of less than 0.4 excluded.
* Behaviour Input is combined scores for questions 6, 11 and 19/20, giving a Likert type variable from 1 (lowest commuter cycling behaviour) to 7 (highest commuter cycling behaviour)

The analysis in this section confirmed that the data collected was suitable to be used to create the latent variable constructs that form the commuter cycling behaviour model to be tested.

4.3.2 Structural Equation Model

As stated in the methods chapter, the theoretical model was adapted for structural equation modelling within IBM SPSS Amos. This model is shown in Figure 16.

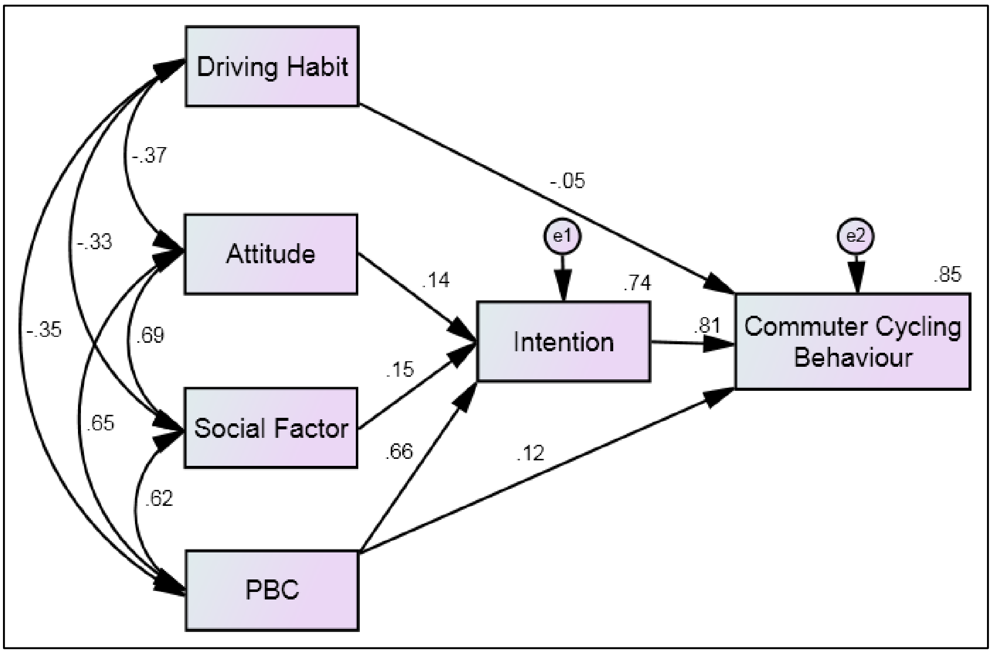

Figure 16: Structural Equation Model adjusted Path Analysis Diagram of the modified Theory of Planned Behaviour model for Commuter Cycling Behaviour

A wide range of goodness-of-fit statistics exists in structural equation modelling. This study uses the measures that have been commonly reported and accepted in the literature (Bamberg*, et al.*, 2007; Byrne, 2010; Hu & Bentler, 1999; Schermelleh-Engel*, et al.*, 2003; Schumacker & Lomax, 2004). As discussed in the methods chapter, the goodness-of-fit of a model to the data needs to be a judgment based on the goodness-of-fit statistics, the sample size, the characteristics of the data and the literature (Byrne, 2010; Cervero & Murakami, 2010). Table 7 shows the goodness-of-fit for the proposed model. GFI, CFI and TLI all indicate a good to very good fit. RMSEA and the χ^2 statistics fall outside the cut-off values, suggesting that the model is not a good fit. However, these statistics are affected by the sample size, with large sample sizes leading to poor results (Schermelleh-Engel*, et al.*, 2003; Schumacker & Lomax, 2004). Therefore, it is reasonable to conclude that despite the RMSEA and χ^2 results, the model is a good fit to the data collected. This suggests that the behaviour model proposed is applicable to commuter cycling behaviour, at least for this sample.

Table 7: Goodness-of-fit statistics for the proposed structural equation model in Figure 16

Measure	Value
N	778
χ^2	37.551
Degrees of freedom (df)	3
χ^2/df	12.517
GFI (>0.950)	0.985
CFI (>0.900)	0.991
TLI (>0.900)	0.953
RMSEA (≤0.08)	0.122

Having established that the model is suitable, we can now look at how the latent variables relate to each other. Figure 16 shows the path analysis model. Double-headed arrows indicate covariance between variables. The number associated with each of these arrows indicates the size and direction of these relationships. Single-headed arrows indicate direct effects of one variable on the other. The number associated with each of these arrows is the standardised direct effect, again showing size and direction of the relationship. The numbers to the top right of the Intention and Commuter Cycling Behaviour boxes are the squared multiple correlation coefficients (R^2). These numbers indicate the proportion of variance of the variables that is explained by the model.

Driving Habit Construct

The model shows that Driving Habit co-varies inversely with Attitude (-0.37, $p<0.001$), Social Factor (-0.33, $p<0.001$) and PBC (-0.35, $p<0.001$). As Driving Habit increases these other variables decrease.

Driving Habit also has a slight negative effect on Commuter Cycling Behaviour (-0.05, $p=0.01$). As Driving Habit increases Commuter Cycling Behaviour gradually decreases.

Attitude Construct

Attitude co-varies with Social Factor (0.69, $p<0.001$) and PBC (0.65, $p<0.001$). As Attitude increases, so too do Social Factor and PBC.

Attitude also has a small positive, direct effect on Intention (0.14, $p<0.001$). An increase in Attitude leads to a slightly greater intention to commute by bicycle.

Social Factor Construct

The Social Factor construct co-varies with PBC (0.62, $p<0.001$) and has a small positive, direct effect on Intention (0.15, $p<0.001$). As the Social Factor construct increases, an increase in PBC is also likely to be seen. This increase is also likely to lead to a gradual increase in intention to commute by bicycle.

Perceived Behavioural Control (PBC) Construct

PBC has a strong direct effect on Intention (0.66, $p<0.001$) and appears to be the main antecedent variable of Intention in this sample. It also has a small positive, direct effect on Commuter Cycling Behaviour (0.12, $p<0.001$). An increase in PBC will lead to a greater intention to commute by bicycle, but also an increase in the likelihood that this intention will lead to a positive commuter cycling behaviour, by acting directly on both variables.

Intention Construct

The antecedent variables of Attitude, Social Factor and PBC account for 74% of the variance in Intention ($R^2=0.74$, $p<0.001$).

Intention also appears to have the largest direct effect on Commuter Cycling Behaviour (0.81, $p<0.001$).

Commuter Cycling Behaviour Construct

The model tested explains 85% of the variance in Commuter Cycling Behaviour seen in these data ($R^2=0.85$, $p<0.001$). The direct effects on behaviour are from Driving Habit (-0.05, $p=0.001$), PBC (0.12, $p<0.001$), and Intention (0.81, $p<0.001$).

There are also indirect effects on behaviour from Attitude (0.113), Social Factor (0.119) and PBC (0.528), which are mediated through Intention.

This suggests that all of the antecedent variables mentioned here, but particularly Intention and PBC, are important in determining Commuter Cycling Behaviour. However, as the explained variance is not 100%, there are obviously other factors influencing this behaviour.

4.3.3 Binary Logistic Regression

Binary logistic regression was performed to corroborate the SEM findings and to allow conclusions to be drawn despite the violations of normality of the data, as discussed in the methods chapter (Chapter 3). The Behaviour variable was converted into a binary (yes/no) variable and contextual factors were included, as they were not included in the SEM. Binary logistic regression was used to look at how a positive Commuter Cycling Behaviour (>4 on the scale) was dependent on Attitude, Social Factor, PBC, Habit, Intention and the contextual factors Age, Gender, Income and Education. A positive Cycling Behaviour score means that the person has access to a suitable bicycle, and commutes by bicycle once per week or more, or commutes by bicycle once per month or more and has identified cycling as their main mode of transport for their commute, as well as stating that commuter cycling is a part of their routine and is something that they would typically do[5].

Table 8: Overall binary logistic regression model summary statistics

Overall Model Evaluation			
	χ^2	df	Sig.
Model	848.116	15	0.000
Goodness-of-Fit Test			
	χ^2	df	Sig.
Hosmer-Lemeshow	2.860	8	0.943
R^2-Type Indicators			
Cox & Snell R^2 = 0.679			
Nagelkerke R^2 = 0.920			

[5] See Methods Section for a detailed explanation of how the binary behaviour variable was created.

Table 8 shows the overall logistic regression model summary statistics, including the model significance, goodness-of-fit and R^2-type indicators. The first row indicates that the model is highly significant (χ^2 (15, *N*= 753) = 848.12, $p < 0.001$). This suggests that Behaviour is correlated with the variables in this mode. The Hosmer-Lemeshow Goodness-of-Fit statistic reports a significance of well over 0.05 ($p = 0.943$) showing that there is no significant difference between the observed results (frequencies of 'yes' and 'no' in the Behaviour variable) and those predicted by the model (Lemeshow & Hosmer, 1982). This means that the model is a good fit to the data.

Table 9: Binary Logistic Regression predictor variable coefficients and significances

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for EXP(B)	
								Lower	Upper
Step 1[a]	ATTITUDE	.990	.352	7.906	1	.005	2.692	1.350	5.370
	SOCIAL	.888	.273	10.564	1	.001	2.431	1.423	4.155
	PBC	.720	.249	8.354	1	.004	2.054	1.261	3.346
	HABIT_DR	-.340	.135	6.390	1	.011	.712	.547	.926
	INTENTION	.872	.149	34.430	1	.000	2.391	1.787	3.200
	AGE_REDUX			.840	4	.933			
	AGE_REDUX(1)	.034	1.179	.001	1	.977	1.035	.103	10.430
	AGE_REDUX(2)	-.097	1.164	.007	1	.934	.908	.093	8.889
	AGE_REDUX(3)	.181	1.179	.024	1	.878	1.199	.119	12.098
	AGE_REDUX(4)	.624	1.294	.232	1	.630	1.866	.148	23.581
	GENDER(1)	.361	.486	.553	1	.457	1.435	.554	3.719
	INCOME_REDUX			6.820	3	.078			
	INCOME_REDUX(1)	-1.264	.872	2.101	1	.147	.283	.051	1.560
	INCOME_REDUX(2)	-1.232	.840	2.149	1	.143	.292	.056	1.515
	INCOME_REDUX(3)	.345	.633	.296	1	.586	1.411	.408	4.883
	EDUC_REDUX			3.394	2	.183			
	EDUC_REDUX(1)	1.784	1.021	3.055	1	.081	5.954	.805	44.022
	EDUC_REDUX(2)	.113	.552	.042	1	.838	1.119	.379	3.305
	Constant	-17.535	2.707	41.973	1	.000	.000		

Note. Sig. < 0.05 indicates a significant correlation with the outcome variable (Commuter Cycling Behaviour)

a. Variable(s) entered on step 1: ATTITUDE, SOCIAL, PBC, HABIT_DR, INTENTION, AGE_REDUX, GENDER, INCOME_REDUX, EDUC_REDUX.

Table 9 shows that when contextual factors (Age, Gender, Income and Education) are controlled for, Attitude, Social Factor, PBC and Intention all have a highly significant, large, positive effect on the outcome variable of Commuter Cycling Behaviour. Driving

Habit, on the other hand, has a significant, but smaller, negative effect. When the behavioural antecedent variables are controlled for, Age, Gender, Income and Education do not have a significant effect on the outcome variable. This suggests that the effect they do have acts through these antecedents.

Table 10: Observed and predicted frequencies of commuter cycling by logistic regression

Observed			Predicted: Commuter Cycling Behaviour (Binary) No	Predicted: Commuter Cycling Behaviour (Binary) Yes	Percentage Correct
Step 1	Commuter Cycling Behaviour (Binary)	No	451	17	96.4
		Yes	11	274	96.1
	Overall Percentage				96.3

Note. a. The cut value is 0.500
Sensitivity= 274/(11+274)= 96.1%
Specificity= 451/(451+17)= 96.4%
False Positive= 17/(17+274)= 5.84%
False Negative= 11/(11+451)= 2.38%

Table 10 shows the percentage of correct predictions that the proposed model was able to make. The model has been used to predict the Commuter Cycling Behaviour outcome of individuals based on the scores for the predictor variables (in Table 9 above). The frequencies of the predicted positive and negative responses are then compared to the frequencies of the observed positive and negative values in the Commuter Cycling Behaviour variable, to see how accurate the model is. As shown in Table 10, this model was able to correctly predict 96.3% of outcome events, with a sensitivity of 96.1% and a specificity of 96.4%. This is a very high correct prediction rate, indicating that Attitude, Social Factor, PBC, Driving Habit and Intention are very strong predictors of Commuter Cycling Behaviour. This confirms the results found in the SEM, where 85% of the variance in Commuter Cycling Behaviour was able to be explained by these factors alone.

4.4 Research Question 3

Research question 3 asked ‘How do the latent variables identified in the model differ between the three Cycling Groups?’ To answer this question, one-way ANOVA was used to assess the differences in the mean score of the latent variables: Commuter Cycling Behaviour, Intention, Attitude, Social Factor, PBC and Driving Habit, between the three cycling groups. Where the ANOVA found a significant difference, the post-hoc test, Tukey HSD, was used to determine which groups were responsible for these differences.

The results of these tests for each latent variable are now presented. The means for each group are presented graphically with the ANOVA results included in the caption. Significant differences identified through Tukey HSD are shown as asterisks above the corresponding group.

4.4.1 Commuter Cycling Behaviour

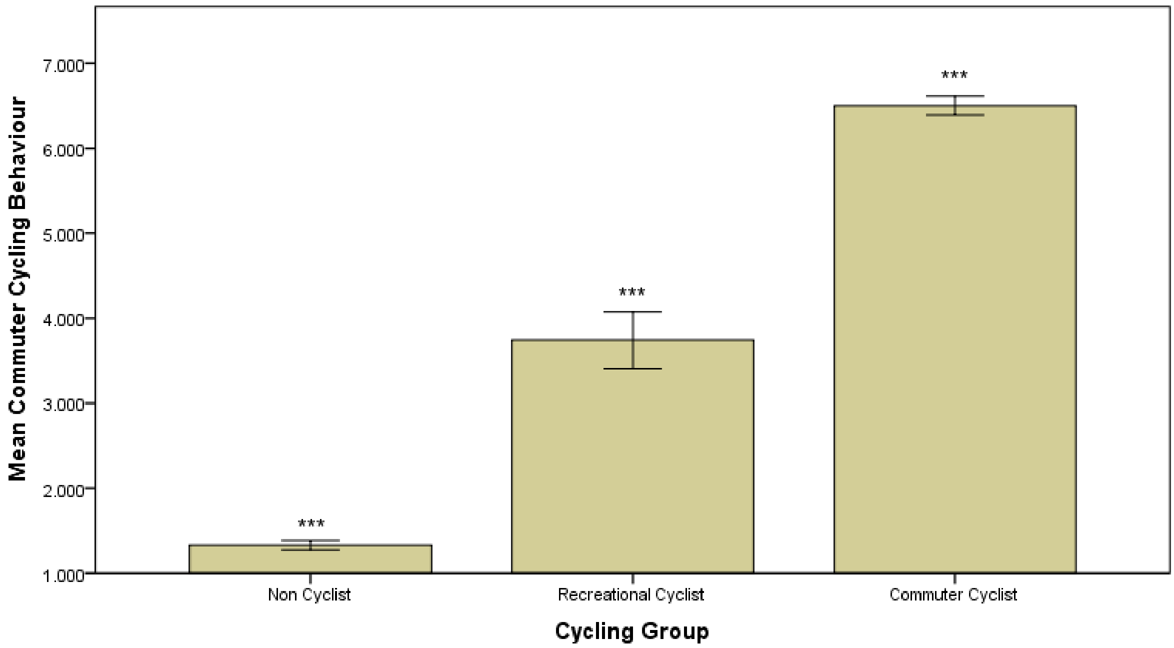

*Figure 17: Mean Commuter Cycling Behaviour scores for the three Cycling Groups. Error bars indicate 95% CI. One-way between groups ANOVA test $F(2, 775) = 1447.76$, $p < 0.001$. *** indicates $p < 0.001$ from Tukey HSD.*

Figure 17 shows the mean Commuter Cycling Behaviour scores for each Cycling Group. A '1' on the scale indicates 'no stated commuter cycling behaviour[6]'. A '7' on the scale

[6] No access to a suitable bicycle, never cycles to work or study and strongly disagrees that commuter cycling is in their routine or is something they would typically do.

indicates a ‘very strong commuter cycling behaviour’[7]. The one-way ANOVA shows that there is a significant difference between the mean Commuter Cycling Behaviour scores of the three groups ($p < 0.001$). Tukey HSD has identified that all three groups are significantly different from each other (all $p < 0.001$). As is to be expected, Non Cyclists have a very low mean behaviour score ($M = 1.33$, $SD = 0.56$), indicating that they do not commute by bicycle and do not consider it part of their routine. Also as expected, Commuter Cyclists score highly ($M = 6.50$, $SD = 0.84$). Recreational Cyclists’ mean score is fractionally below the midpoint in the scale ($M = 3.74$, $SD = 2.16$). The mean score of Recreational Cyclists is slightly closer to that of Non Cyclists than to that of Commuter Cyclists.

4.4.2 Intention

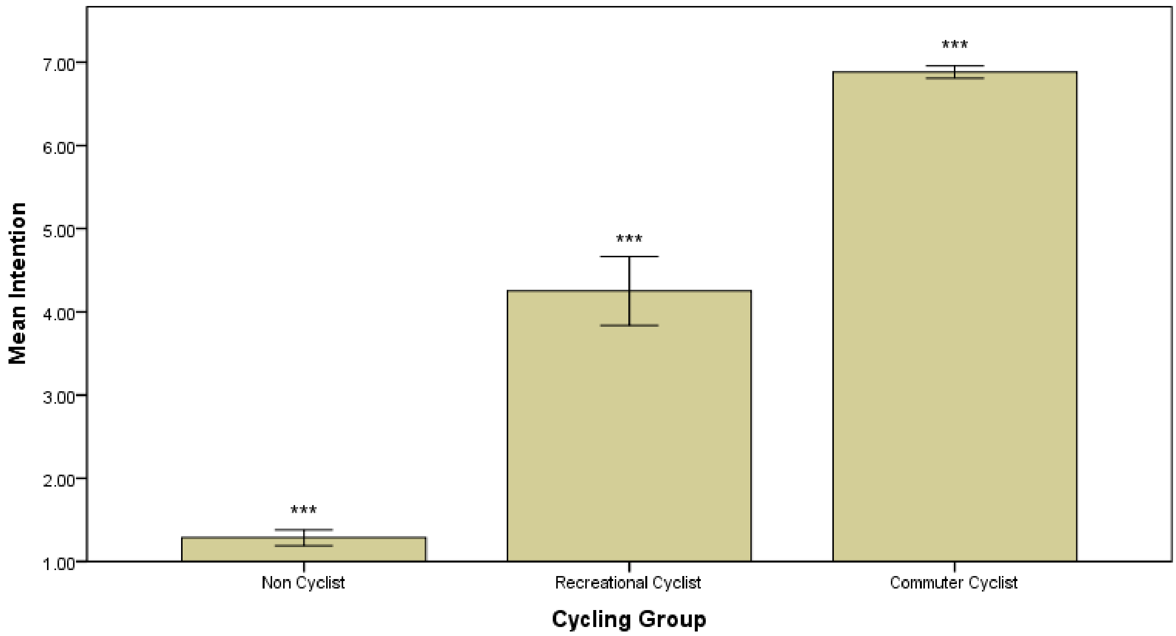

*Figure 18: Mean Intention scores for the three Cycling Groups. Error bars indicate 95% CI. One-way between groups ANOVA test F(2, 775) = 1127.51, p < 0.001. *** indicates p < 0.001 from Tukey HSD.*

Figure 18 shows mean Intention scores for the three Cycling Groups. A ‘1’ on the scale indicates no intention to commute by bicycle in the next few weeks. A ‘7’ on the scale indicates a strong intention to commute by bicycle in the next few weeks. Once again,

[7] Cycles three or more times a week to work or study and strongly agrees that cycling to work is in their routine and is something they would typically do.

the one-way ANOVA shows that there is a significant difference between the mean Intention scores of the three groups ($p < 0.001$). Tukey HSD identifies that all three groups are significantly different from each other (all $p < 0.001$), with Non Cyclists having a very low mean Intention ($M = 1.29$, $SD = 0.95$), Commuter Cyclists having a very high mean Intention ($M = 6.88$, $SD = 0.59$) and Recreational Cyclists falling slightly higher than the mid-point with a mean Intention of 4.25 ($SD = 2.66$). The mean Intention score for Recreational Cyclists is slightly closer to that of Commuter Cyclists than that of Non Cyclists.

4.4.3 Attitude

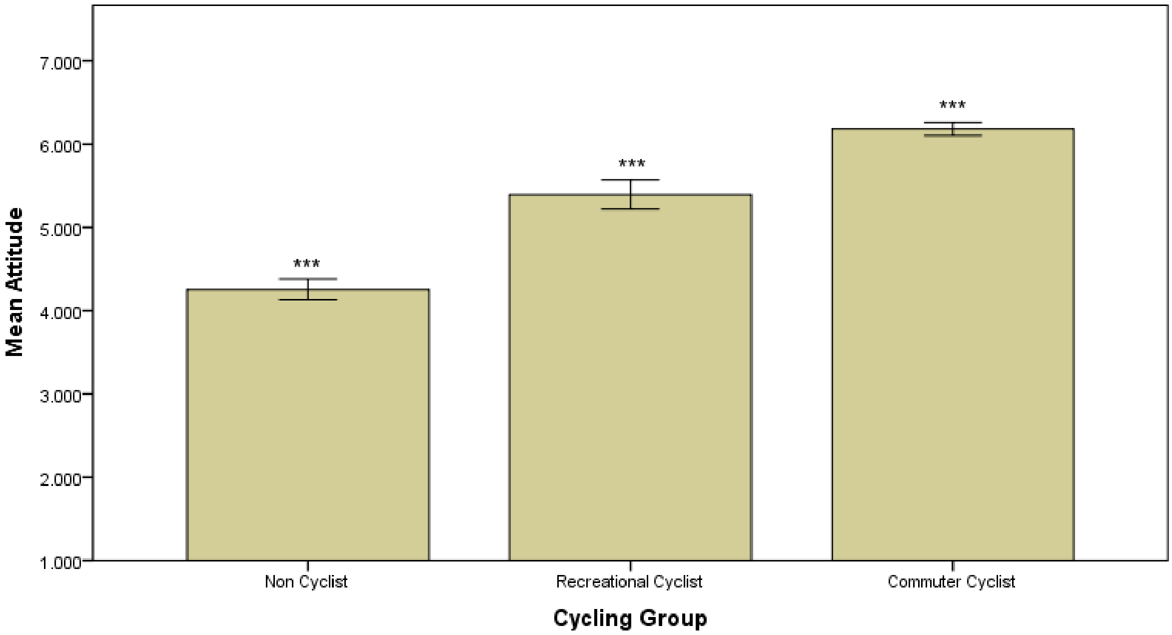

*Figure 19: Mean Attitude scores for the three Cycling Groups. Error bars indicate 95% CI. One-way between groups ANOVA test F(2, 775) = 238.60, p < 0.001. *** indicates p < 0.001 from Tukey HSD.*

Figure 19 shows mean Attitude scores for the three cycling groups. A '1' on the scale indicates a strong negative attitude towards commuter cycling, '4' indicates a neutral attitude and '7' indicates a strong positive attitude. Once again, all three groups had significantly different mean scores for Attitude (ANOVA significance of $p < 0.001$ and Tukey HSD for all three groups of $p < 0.001$).

Interestingly, all of the groups had mean attitudes that were positive towards commuter cycling (above four on the scale). However, as expected Commuter Cyclists had the most positive Attitude ($M = 6.18$, $SD = 0.59$), followed by Recreational Cyclists

(M = 5.40, SD = 1.13) and then Non Cyclists (M = 4.25, SD = 1.26). The mean Attitude score for Recreational Cyclists is closer to that of Commuter Cyclists than to that of Non Cyclists.

4.4.4 Social Factor

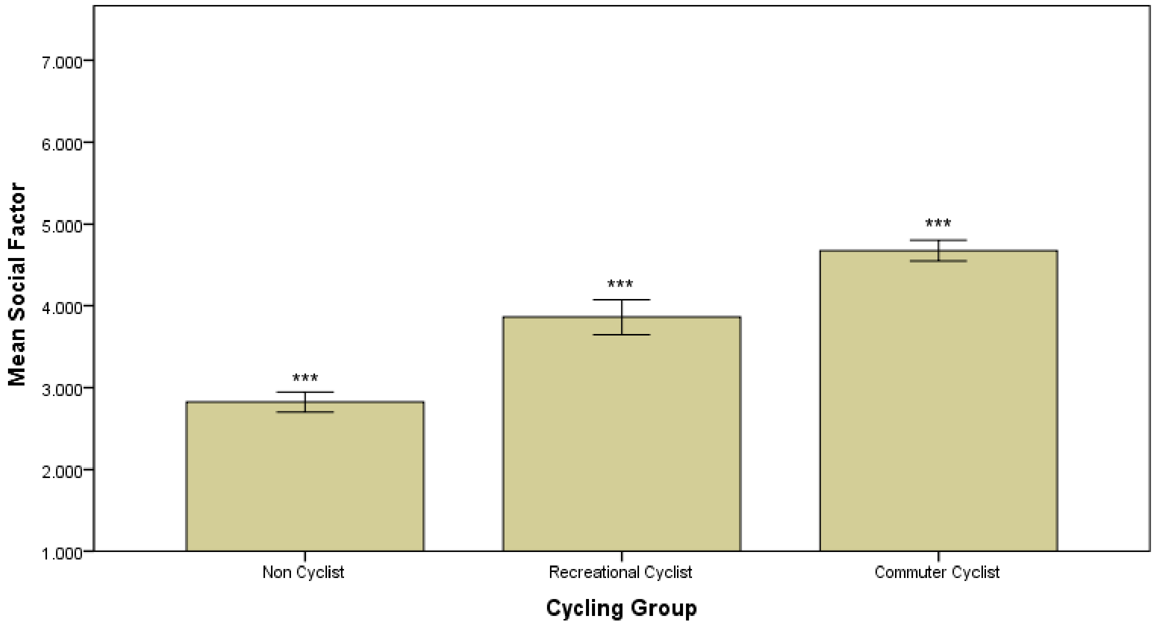

*Figure 20: Mean Social Factor scores for the three Cycling Groups. Error bars indicate 95% CI. One-way between groups ANOVA test F(2, 775) = 176.34, p < 0.001. *** indicates p < 0.001 from Tukey HSD.*

Figure 20 shows mean Social Factor scores for the three cycling groups. A '1' on the scale indicates that social norms and beliefs of others with regard to commuter cycling are perceived as strongly negative, '4' indicates a perception of neutrality and '7' indicates a strongly positive perception. Here too, the three groups had significantly different mean scores (ANOVA significance of $p < 0.001$ and Tukey HSD for all three groups of $p < 0.001$), meaning that the three groups perceive the social norms and roles around commuter cycling, and the beliefs of others about commuter cycling differently. However, no score was particularly high, with Commuter Cyclists recording the highest mean of 4.67 (SD = 0.97), only slightly above neutral (4). Recreational Cyclists scored just below neutral (M = 3.86, SD = 1.37) and Non Cyclists gave the lowest mean score of 2.82 (SD = 1.24). The mean score of Recreational Cyclists is closer to that of Commuter Cyclists than that of Non Cyclists.

4.4.5 Perceived Behavioural Control

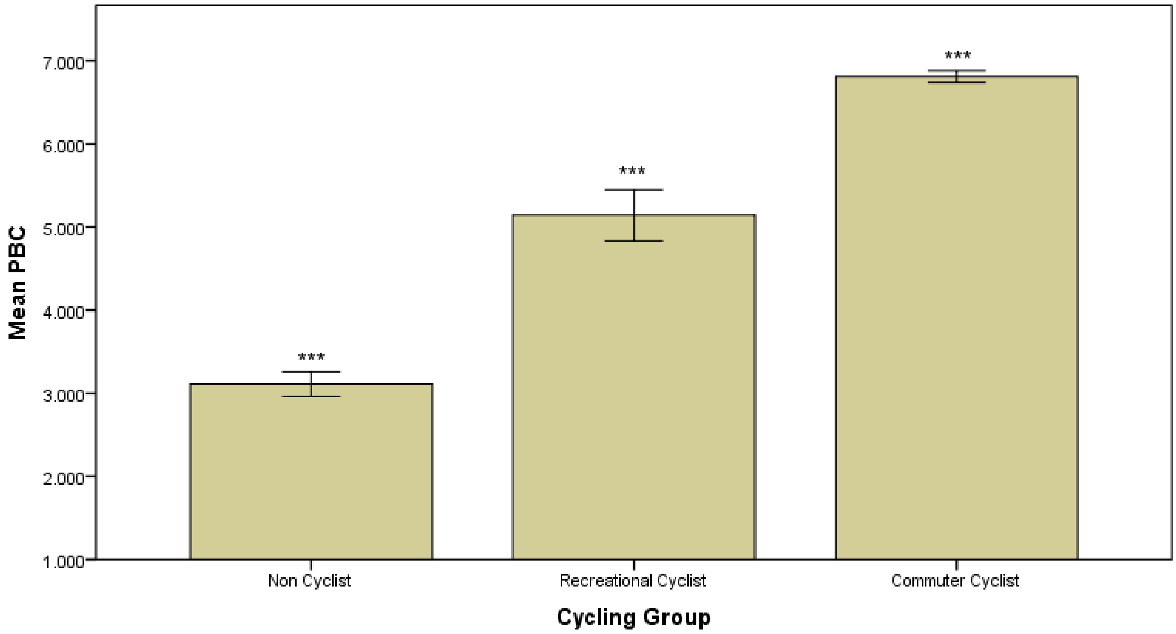

*Figure 21: Mean PBC scores for the three Cycling Groups. Error bars indicate 95% CI. One-way between groups ANOVA test F(2, 775) = 495.71, p < 0.001. *** indicates p < 0.001 from Tukey HSD.*

Figure 21 shows mean PBC scores for the three cycling groups. ‘1’ on the scale indicates a perception that the respondents have no control over their actions in terms of cycling to work or study, while a ‘7’ indicates the perception that they have full control. Again, the three groups had significantly different mean scores for PBC (ANOVA significance of $p < 0.001$ and Tukey HSD for all three groups of $p < 0.001$). Non Cyclists were the only group to record mean score below the midpoint of the scale ($M = 3.11$, $SD = 1.50$). Recreational Cyclists recorded a mean score of 5.14 ($SD = 1.98$), indicating a reasonably high PBC. Commuter Cyclists scored the highest ($M = 6.81$, $SD = 0.54$), which is to be expected as they already commute by bicycle so feel they have a high level of control over this. The mean PBC score for Recreational Cyclists is closer to that of Commuter Cyclists than that of Non Cyclists.

4.4.6 Driving Habit

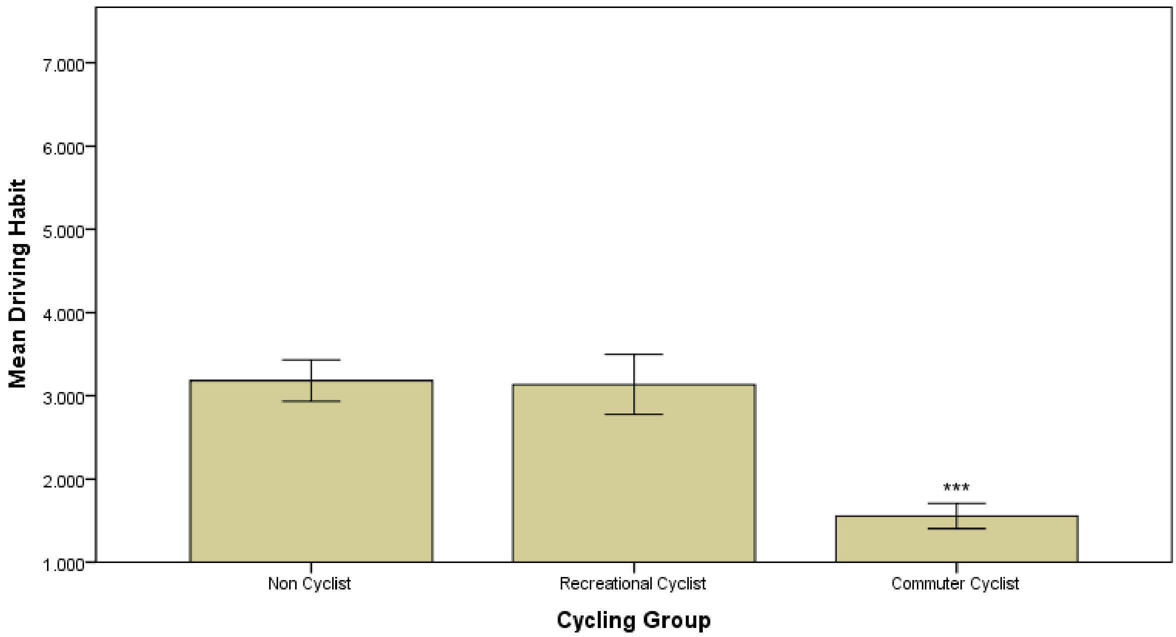

*Figure 22: Mean Driving Habit scores for the three Cycling Groups. Error bars indicate 95% CI. One-way between groups ANOVA test F(2, 775) = 44.92, p < 0.001. *** indicates p < 0.001 from Tukey HSD.*

Figure 22 shows mean commuter Driving Habit scores for the three cycling groups. A '1' on the scale indicates a very weak commuter driving habit (very unlikely to commute by car), while a '7' indicates a very strong commuter driving habit (very likely to regularly commute by car). The ANOVA test found a significant difference between groups (ANOVA significance of $F(2, 775) = 44.92$, $p < 0.001$). However, the Tukey HSD test identified that this difference was only between the Commuter Cyclist group (M = 1.56, SD = 1.16) and the two other groups ($p < 0.001$). There was no significant difference (p = 0.971) between the mean scores of the Non Cyclist and Recreational Cyclist groups (with M = 3.18, SD = 2.48 and M = 3.14, SD = 2.33 respectively).

4.4.7 Gender Differences

The literature commonly finds that transport cycling perceptions and behaviour differ between men and women (Garrard, *et al.*, 2011). As such, it was important for this research to investigate Commuter Cycling Behaviour and antecedents by gender to see if any further insights can be gained.

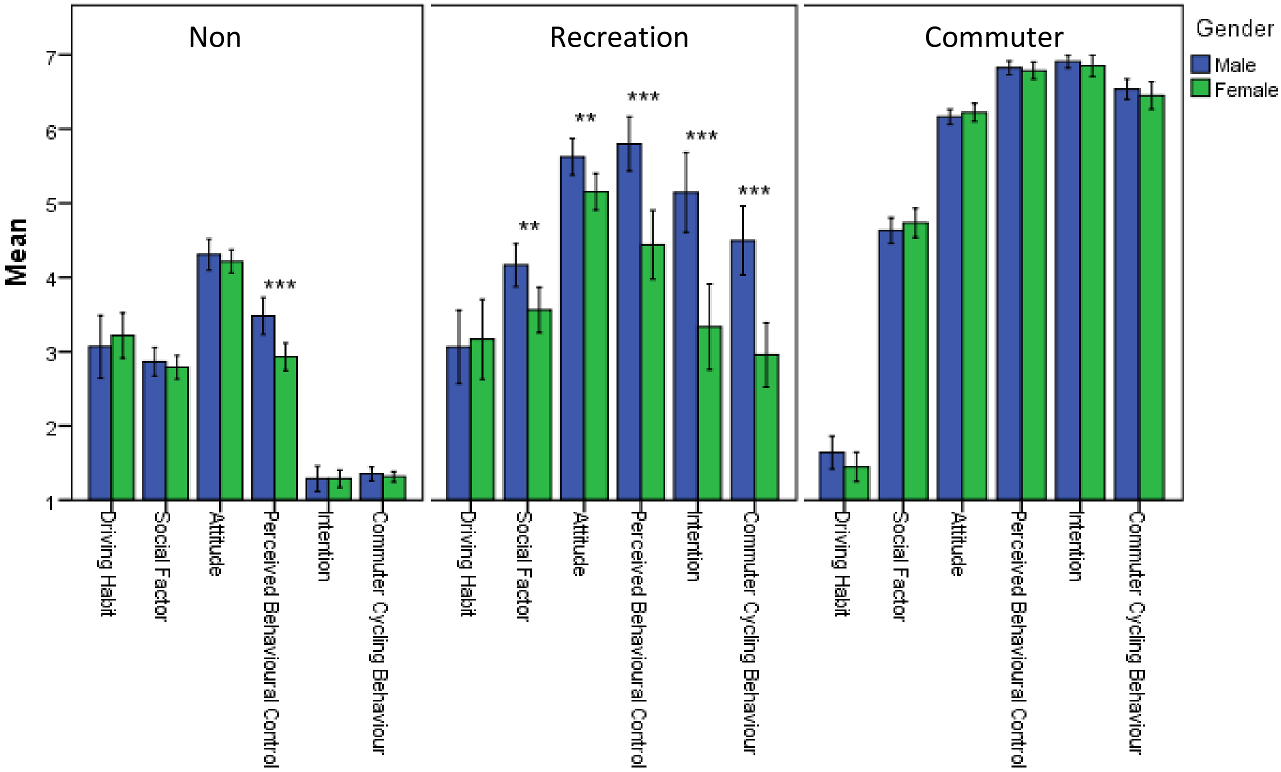

*Figure 23: Mean scores for the behaviour and antecedent latent variables by gender and Cycling Group. Error bars indicate 95% CI. *** indicates p <= 0.001, ** indicates p <= 0.01 from one-way ANOVA[8].*

Figure 23 shows a comparison of males and females in the three cycling groups, in terms of their behavioural and antecedent constructs' mean scores. One-way ANOVA found no significant difference between the Attitude, Social Factor, PBC, Driving Habit, Intention and Commuter Cycling Behaviour constructs of men and women within the commuter cycling group.

In terms of these constructs the only significant difference between men and women in the Non Cycling group is seen in PBC ($F(1, 387) = 11.97$, $p = 0.001$). Here, men have a mean PBC score of 3.48 ($SD = 1.42$) and women have a slightly lower mean PBC score of 2.93 ($SD = 1.50$).

There are, however, significant differences in the mean score for all constructs, except Driving Habit, between male and female Recreational Cyclists. The significant differences are outlined in Table 11, which shows that women report lower mean

[8] The scales for each variable have been explained earlier in descriptions of Figure 17 to Figure 22

scores than men for Attitude, Social Factor, PBC, Intention and Commuter Cycling Behaviour.

Table 11: Summary of ANOVA statistics of Male vs. Female comparison of behaviour and antecedent variable scores for Recreational Cyclists

Construct	Male		Female		ANOVA Statistics
	Mean	SD	Mean	SD	
Attitude	5.62	1.13	5.16	1.10	$F(1, 159) = 7.14, p = 0.008$
Social Factor	4.17	1.32	3.56	1.35	$F(1, 159) = 8.22, p = 0.005$
PBC	5.80	1.68	4.44	2.06	$F(1, 159) = 21.24, p < 0.001$
Intention	5.14	2.47	3.33	2.56	$F(1, 159) = 20.90, p < 0.001$
Commuter Cycling Behaviour	4.50	2.12	2.96	1.91	$F(1, 159) = 23.26, p < 0.001$

Although these differences exist between men and women within the groups, the trends and differences established earlier in Figures 17 to 22 do not change when the groups are split by gender and then compared. The tables of ANOVA and Tukey HSD results for this analysis can be found in Appendix F.

4.4.8 Summary

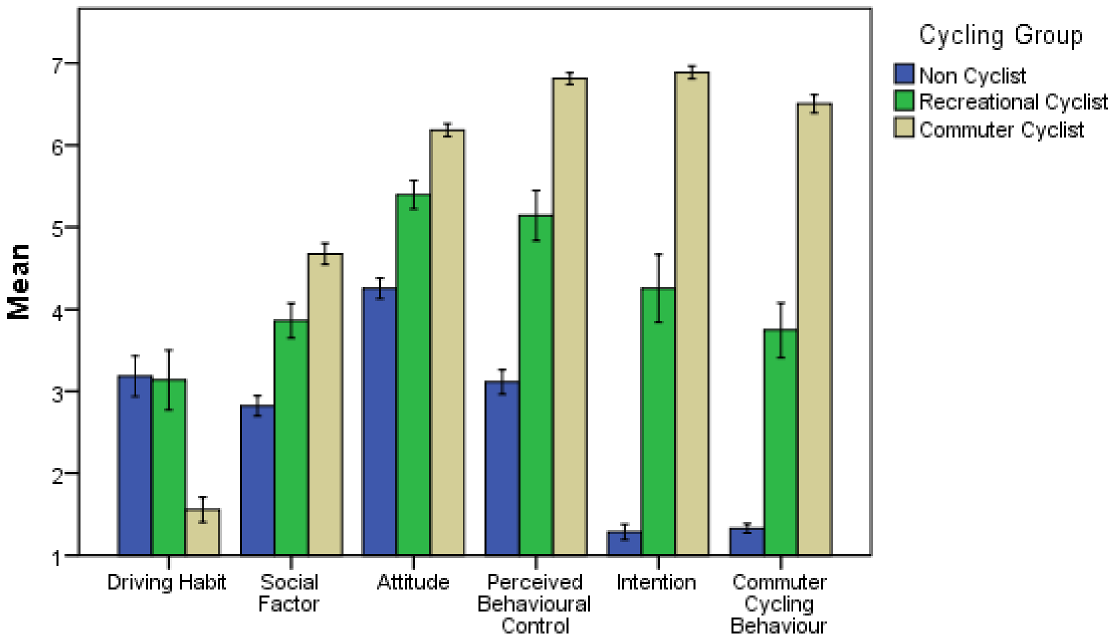

Figure 24: Summary chart of mean scores of all behaviour and antecedent variables for the three cycling groups. Error bars indicate 95% CI[9].

This summary graph (Figure 24) shows the clear trend in mean Commuter Cycling Behaviour score and its antecedent variables across the groups. Non Cyclists show higher driving habit and the lowest Attitude, Social Factor, PBC, Intention and Behaviour scores. Recreational Cyclists still have the higher Driving Habit, but have increased Attitude, Social Factor, PBC and Intention means, and have the corresponding increase in Behaviour. Commuter Cyclists have a very low Driving Habit and very high mean scores for Attitude, Social Factor, PBC and Intention, and fittingly, have a very high mean score for Commuter Cycling Behaviour.

These analyses of variances in the behavioural and antecedent constructs across the three groups clearly show that, within this sample, Recreational Cyclists have more favourable attitudes, social perceptions, PBC and intentions toward commuter cycling than Non Cyclists. They also have a significantly higher level of commuter cycling behaviour. All of the behavioural antecedents of Recreational Cyclists, with the

[9] The scales and statistical significances for each variable have been explained earlier in descriptions of Figure 17 to Figure 22

exception of Driving Habit, were closer to those of Commuter Cyclists than Non Cyclists.

In order to look at some of the potential reasons behind the differences in behavioural antecedents between the three groups, it is necessary to look at some of the stated motivations and barriers to commuter cycling of this sample. The next section applies qualitative analysis to further explore these beliefs and perceptions.

4.5 Research Question 4

Research question 4 asked; 'Why do people cycle for transport and recreation and are these reasons similar?' To address this question the stated motivations for recreational cycling and commuter cycling were analysed using thematic coding to identify the common and meaningful themes that respondents mentioned in response to questions 12 and 14 of the survey. Question 12 was answered by all Commuter Cyclists (n = 224) and by some Recreational Cyclists who also commuted by bicycle at least once per month (n = 92). Respondents to question 14 included Recreational Cyclists (n = 158) and Commuter Cyclists who also stated that they cycled for recreation once or more a month (n = 148) (see methods, Chapter 3 for group classification criteria).

The themes are set out and defined below. The contribution of these themes to recreational cycling and commuter cycling are then discussed and compared, with this research question in mind.

The themes identified as stated motivations for recreational and/or commuter cycling are:

Enjoyment: this theme captures the fun, enjoyable and exciting aspects of cycling. People who talked about this theme simply enjoyed the experience of cycling for recreation or to work or study. Some mentioned why they enjoyed it (such as "the thrill", being outdoors or in nature, in the fresh air, the sense of freedom and exploring), while others just stated that they enjoyed it or "it's fun".

Health: This theme covers the beneficial aspects of using a bicycle, for both physical and mental health. This included statements about fitness improvements, mood, relaxation and wellbeing.

Social: This theme includes responses that mentioned spending time with friends and family as a main reason for cycling.

Cost: This theme captures the financial reasons for choosing to cycle, where cycling was seen as being cheap, free, affordable, etc.

Convenience: This theme covers the opinions that cycling is simple and easily fits with the respondents' lifestyles. This included individuals who did not want to conform to the timetables of buses or the perceived hassle of parking a car. This theme also covers those who view cycling as their only viable transport option, either because they cannot use a car or public transport (such as no bus servicing their home, no drivers' licence), or they dislike the alternatives ("I hate sitting in traffic", "I can't stand the bus").

Time: This theme encapsulates the descriptions of cycling as being fast and saving time.

Sustainability: This theme captures the environmentally beneficial aspects of cycling. People mentioned concern for their carbon emissions, other pollution, environmental protection and a feeling of moral obligation.

There were simply three themes identified as motivations for recreational cycling within this sample. The main theme was enjoyment, with 83% of respondents mentioning this. The second most common theme mentioned was health, being mentioned by 63% of respondents. Less commonly mentioned, but still of importance, was the social theme (23%).

The reasons given for choosing to commute by bicycle were more diverse. The health theme was the most frequently mentioned, with 71% of respondents citing health and fitness reasons for commuting by bicycle. Cost, convenience, time and enjoyment were all mentioned at similar frequencies (54%, 49%, 45% and 45%, respectively). Less commonly mentioned was sustainability, which occurred in 18% of responses.

There are clear similarities and differences between the reasons stated for recreational and commuter cycling. A greater range of reasons was stated for commuter cycling, many of these being more practical in nature (such as cost, time and convenience). However, there were two themes that occurred as reasons for both types of cycling.

These were health and enjoyment, and were major contributors to both recreational and commuter cycling (with either, or both, mentioned in 97% and 83% of responses, respectively).

4.6 Research Question 5

Research question 5 asked; 'For Non Cyclists and Recreational Cyclists, what are the barriers to commuting by bicycle, how do these differ and how can they be overcome?'

This section firstly looks at the perceived barriers to commuter cycling mentioned by the Non Cyclist and the Recreational Cyclist groups in response to question 23 of the survey. These themes are explained and then compared between the groups.

Next, the responses to question 24 of the survey are analysed to identify, and compare, what each group believes would most effectively address these barriers and encourage them to commute by bicycle.

4.6.1 Barriers

The themes that occurred as perceived barriers to commuter cycling are:

Weather: This theme covers those who stated that their perception of bad weather (e.g. strong wind, rain etc.) stops them from cycling to work or study.

Hills: This theme contains those who feel that the steep hills of Wellington prevent them from commuting by bicycle.

Equipment: This theme incorporates responses that stated that a lack of equipment stops the respondent from cycling.

Distance: this theme covers responses that mentioned distance or time as a barrier to commuting by bicycle. It includes perceptions that the distance is too far or too short, as well as it taking too long to cycle.

Danger: This theme covers perceived danger as a barrier to cycling to work or study. It includes statements that indicate perceived safety concerns due to traffic volumes, as well as the width of the roads and driver behaviour.

Inexperience: This theme captures respondents who felt they lacked the required skill, experience or fitness to commute by bicycle.

Destination Facilities: This theme includes those responses that cited a lack of suitable storage, showering and changing facilities at their destination as a barrier to them commuting by bicycle. It also includes people who stated that they did not want to cycle as they would be in a sweaty and dishevelled state while at work.

Trip Chaining and Luggage: This theme covers those who viewed cycling as not possible because of the need to make other trips on the way to work or home (such as taking children to school, going for drinks after work, etc.). It also covers those that said they could not cycle to work or study because cycling would not allow them to transport the equipment (e.g. tools, clothes and other work related gear) that they needed for the day.

Otherwise impractical: This theme includes those who gave other reasons as barriers to them commuting by bicycle, including physical impairments, a dislike of the legal requirement to wear a helmet, the lack of integration of cycling with public transport, and simply not wanting to cycle (e.g. “I prefer to run” or “I wouldn’t cycle anyway”).

None: Some respondents stated that they had no barriers to commuting by bicycle and they currently always commute by bicycle. This theme captures those people.

Table 12 shows the percentage of respondents from each group that mentioned the corresponding barrier to commuting by bicycle when asked ‘What are the barriers to you cycling (or cycling more often) to work or study?’

Table 12: Percentage of respondents who mentioned each commuter cycling barrier

	Theme									
Cycling Group	Danger	Distance	Equipment	Hills	Weather	Trip Chaining	Inexperience	Destination Facilities	Otherwise Impractical	None
Non Cyclist	51%	35%	23%	23%	14%	13%	8%	8%	4%	0%
Recreational Cyclist	48%	35%	4%	17%	31%	15%	1%	13%	1%	9%

Overall, the main barriers to commuter cycling that were stated are perceived danger, weather and distance. Non Cyclists mention the theme of perceived danger most commonly, followed by distance, lack of equipment and hills. Minor themes for Non Cyclists are weather, trip chaining and luggage, inexperience, a lack of destination facilities and that it is otherwise impractical. No Non Cyclist stated that they saw no barriers to commuter cycling.

Recreational Cyclists again gave perceived danger as the most common barrier to commuter cycling. Two other main barriers stated for this group were distance and weather. The less commonly mentioned barriers were hills, trip chaining and luggage, lack of destination facilities, lack of equipment, inexperience and it being otherwise impractical. Nine per cent of Recreational Cyclists stated that they saw no barriers to commuting by bicycle.

Between the two groups, the barriers of perceived danger and distance were mentioned at a very similar frequency, indicating that these groups are very similar with regard to the perception of these two issues. However, recreational cyclists were slightly less likely to perceive hills as a barrier to commuter cycling, and were far more likely to have the required equipment and experience to commute by bicycle. Recreational Cyclists also stated more often that a lack of showering and storage facilities at their destination prevented them from commuter cycling. Additionally, they were much more likely to state that they perceived no barriers to cycling to work or study.

Recreational cyclists were twice as likely to give weather as a reason for not cycling as much as they could. Interestingly, this is very similar to Commuter Cyclists for whom 49% stated that weather was a barrier to them cycling more often. This is interesting because for Recreational and Commuter Cyclists it was common for specific cases of bad weather to be cited as a reason for not cycling on occasion, for example:

> *"Wind (proper gusts) puts me off cycling, have been blown off bike before, and don't overly like the rain either - showers are ok, but put rain and wind together I will take the car."*
>
> *"Rain and/or stormy weather"*
>
> *"Weather (wind more than rain - I hate pedalling into a strong headwind)"*

When Non Cyclists mentioned the weather it was usually in a more general way, as a reason why they would not take up commuter cycling. For example:

> *"[T]he weather in [W]ellington"*
>
> *"[T]he uncertainty of Wellington weather"*
>
> *"[W]eather [is] too unfriendly"*

4.6.2 Interventions

The themes that occurred in responses to question 24 on the interventions that would encourage commuter cycling are:

Road infrastructure: This theme covered those who mentioned changes to roads that improved their safety as something that would encourage them to commute by bicycle. This was predominantly the provision of cycle ways separated from traffic, but also included those who mentioned simply 'improved' or 'better' roads.

Cultural shift: This theme contains the responses who addressed the need for a change in the way society views cyclists and their rights on the road to encourage them to commute by bicycle. A large part of this was addressing the attitude and behaviour of car and bus drivers.

Destination facilities: This theme included those who stated that suitable storage, showering and changing facilities at their destination would encourage them to commute by bicycle.

Equipment: This theme encompasses those who said having the right equipment would encourage them to cycle to work or study.

Experience: This theme contains those that stated that having better cycling skills, through more experience or training would encourage them to cycle more often.

Public Transport Integration: Some people mentioned that being able to easily take their bicycle on the bus, train or ferry would encourage them to cycle more frequently to work or study. This theme covers those responses.

Nothing: This theme is for those respondents who stated that nothing would encourage them to cycle, or cycle more frequently, for their commute.

Table 13: Percentage of respondents who mentioned each commuter cycling intervention

Cycling Group	Theme						
	Road Infrastructure	Equipment	Destination Facilities	Cultural Shift	Experience	Public Transport Integration	Nothing
Non Cyclist	45%	12%	8%	6%	5%	3%	39%
Recreational Cyclist	60%	4%	16%	16%	0%	4%	28%

As shown in Table 13, Non Cyclists most frequently mentioned the need for significant road infrastructure improvements to encourage them to cycle to work of study. The second most commonly mentioned prerequisite to taking up cycling was having the appropriate equipment, usually having a bicycle. Less commonly mentioned was the need for better showering and storage facilities, a cultural shift, more experience and public transport integration. 39% of Non Cyclists stated that nothing would encourage them to take up commuter cycling.

By far the most frequently mentioned intervention to encourage commuter cycling among the Recreational cyclist group was improvements in road infrastructure for cyclists. This was distantly followed by the provision of destination facilities and a cultural shift in favour of cycling. Having the appropriate equipment was rarely mentioned as likely to encourage an increase in commuter cycling, as was better integration with public transport. More experience or cycle skills training were not mentioned at all. 28% of Recreational Cyclist respondents stated that nothing would make them cycle, or cycle more often, to work or study. Of this 28%, half of them (14%) already commute by bicycle once per month or more and half do not (14%).

Road safety improvements, destination facilities and a cultural shift were far more important for Recreational Cyclists than Non Cyclists, while experience and equipment were less. This indicates that the concerns of Recreational Cyclists are more to do with the experience of cycling, whereas Non Cyclists are more concerned with the enabling circumstances. Far fewer Recreational Cyclists stated that nothing would make them start cycling to work or study compared to Non Cyclists (14% and 39% respectively).

The next chapter employs the theoretical framework, set out in Chapter 2, to explore the meaning of these results. The strengths and limitations of this work, as well as avenues for further research and policy recommendations are then discussed. Finally, the conclusions of this research project are then presented.

Chapter 5: Discussion and Conclusion

This research set out to determine whether recreational cyclists are more amenable to commuting by bicycle than non-cyclists in the Wellington Region. An empirical model based on individual behaviour theory was employed, along with qualitative analysis, to assess whether recreational cyclists were more prepared and willing to commute by bicycle than non-cyclists. This chapter discusses the results of this research and how these address the research questions set out in Chapter 2. It employs the conceptual framework set out in the literature review and theory sections to provide a broader meaning to these findings. The strengths and limitations of this project, as well as avenues for further research and overall policy recommendations are then discussed, before concluding on the findings of this thesis.

5.1 Results Discussion

Both the quantitative and qualitative results suggest recreational cyclists are more amenable to commuting by bicycle than non-cyclists in the Wellington Region.

The SEM fits the data gathered, and the logistic regression shows that the variables in this model are significantly correlated with commuter cycling behaviour. Although when considered independently socio-economic and demographic characteristics are significantly associated with cycling group (and implicitly, commuter cycling behaviour), when the behavioural antecedent variables are controlled for these significant associations disappear. It is not appropriate to assume that these characteristics (especially age and gender, for example) have no influence on whether one cycles to work or not, as work by Sener*, et al.* (2009) points out. Therefore, these results suggest that the influence that these contextual factors have on behaviour must act through the modelled behavioural antecedents in some way.

The empirical analysis had the limitations of not being able to fully capture context and also not being able to model the feedback loops that were set out in the conceptual theoretical model. However, the constructs used in the SEM were able to explain 85 per cent of the variance in commuter cycling behaviour seen in the sample population and the logistic regression correctly predicted 96 per cent of outcome events. It is logical that much of the influence of context will act through the antecedent variables. Context is also likely to act directly on behaviour (Bamberg*, et al.*, 2007; Ölander &

Thøgersen, 1995; Stern, 2000; Triandis, 1977), and this, along with a broader measure of commuter transport habits, may well account for much of the remainder of the variance in behaviour.

Given this, I believe that we can conclude that the proposed conceptual behaviour model fits the data observed well, and therefore, can be used to model commuter cycling behaviour.

As such, the findings of this research broadly lend support to the application of Ajzen's (1991) Theory of Planned Behaviour, with a 'Social Factor' that combines Ajzen's subjective norms with Triandis' (1979) social factors, and the inclusion of habit as suggested by Bamberg and Schmidt (2003), as a viable behaviour model (however, this model could be strengthened by using a more inclusive indicator of commuter transport habit). As the Theory of Planned Behaviour and other theories suggest, intention has been shown to be the main precursor of behaviour, but is not the only direct influence. Other direct influences on behaviour include habit, perceived behavioural control (PBC) and context, as suggested by many other researchers (such as Ajzen, 2002; Bamberg & Schmidt, 2003; Morley, 2011; Stern, 2000).

In terms of commuter cycling, the most important factor appears to be PBC (the perception of how easy or difficult it is to perform the task in question). This has the greatest influence on intention and, therefore, behaviour. Social Factors and Attitude have less of an effect, but still contribute. This means that viewing the outcomes of cycling to work as positive, and evaluating those outcomes as worthwhile, leads to a stronger intention to cycle, in line with conclusions by Gatersleben and Appleton (2007), Dill and Voros (2007), and Heinen*, et al.* (2010). Perceiving more positive social norms around cycling, having peers who cycle and feeling that cycling fits within one's social group also leads to a stronger intention, as already found by de Bruijn*, et al.* (2005), de Geus*, et al.* (2008), and Dill and Voros (2007). The effect of these factors is not as great as one might initially expect. This is because all three groups had reasonably positive attitudes toward cycling and all had reasonably low perceptions of Social Factors. The similar attitudes could be a result of the snowball sampling method and also the self-selecting nature of online survey participants. The common low Social Factors could well be because cycling is a minority in the Wellington Region (Greater

Wellington Regional Council, 2013) and it is not highly regarded throughout the country (Forbes & McBride, 2013).

While transport habit is important to include in this model, it is likely that with a more complete measure of habit it may have been seen to play more of a role in behaviour, as discussed by many authors such as Bamberg*, et al.* (2003), Schwanen*, et al.* (2012), Verplanken*, et al.* (2008) and de Bruijn and Gardner (2011). However, the results obtained with the commuter driving habit variable are still interesting. The commuter driving habit scores were very low for all groups, suggesting that Wellington commuters might have a low car dependency when commuting. This is supported by commuter mode choice data for Wellington City that shows high levels of walking and public transport use (Land Transport NZ, 2008).

Applying the proposed theoretical model to the three cycling groups shows that recreational cyclists are indeed more amenable to commuting by bicycle than non-cyclists. This gives an indication that promoting recreational cycling may well be effective at encouraging commuter cycling, providing further evidence to support the work by Stuckless (2010), Stinson and Bhat (2004), Koorey*, et al.* (2009) and Sener*, et al.* (2009). The behavioural antecedents of recreational cyclists were closer to those of commuter cyclists than those of non-cyclists, with the exception of commuter driving habit. This could suggest that an increase in recreational cycling may lead to a 'spill-over' into commuter cycling, or at the very least an increase in the number of people who are closer to being ready to commute by bicycle, and who would require less encouragement to become commuter cyclists (Stuckless, 2010).

One of the most interesting results from this analysis arose from comparing PBC between the groups. Recreational cyclists had an average PBC score above the midpoint of the scale, indicating that they felt that it would be relatively easy for them to cycle to work or study if they chose to. Non-cyclists, on the other hand, had an average PBC score below the midpoint, showing that they felt it would be hard to commute by bicycle. As the SEM found that PBC had the biggest influence on behaviour, this is a key difference between the groups, and a key indicator that cycling recreationally is related to a change in the way opportunities and abilities to cycle are perceived. This is interesting because it ties in with work by Bamberg and Schmidt

(1994) and de Geus*, et al.* (2008) which found that cyclists perceive more support for cycling, and more opportunities to cycle, than non-cyclists.

The qualitative responses corroborate this finding and provide further insight into the contextual issues of choosing to commute by bicycle. Generally, these results show that recreational cyclists appear to be more amenable to cycling their commute than non-cyclists. This was highlighted in a range of ways. Firstly, there is a large overlap in the motivation for both types of cycling, with the vast majority of both recreational and commuter cyclists stating that they cycle for health and enjoyment.

Another illustration of the amenability of recreational cyclists to commuter cycling was in the way they perceived barriers to commuter cycling. Many recreational cyclists stated that they had 'no barriers' to commuting by bicycle, while no non-cyclists said this. Additionally, while over a third (39%) of non-cyclists stated that 'nothing' would encourage them to start commuting by bicycle, only 14 per cent of recreational cyclists[10] took this stance.

Furthermore, the barriers that recreational cyclists did mention were more concerned with the experience of cycling than the more fundamental enabling factors (e.g. skills, experience and equipment) that non-cyclists gave as barriers. This suggests that recreational cyclists have the basic capacity to commute by bicycle and have progressed their consideration to the practicalities and process of cycling their commute. In addition, the barriers that recreational cyclists perceive are more limited and specific to certain events (such as very strong wind or heavy rain), as opposed to the broader and more general barriers of non-cyclists ("weather" in general). These findings support a number of studies that have found that non-cyclists perceive barriers to cycling to be much larger than do people who already cycle (For example Bamberg & Schmidt, 1994; de Geus*, et al.*, 2008; Gatersleben & Appleton, 2007; Koorey*, et al.*, 2009; Stuckless, 2010).

Having said this, the overwhelmingly common theme across all three groups was the perceived lack of safety of cycling on Wellington roads. This was primarily due to the lack of cycling infrastructure and the perceived driver behaviour towards cyclists. This

[10] When excluding those recreational cyclists that already commute by bicycle

perception is a fundamental barrier that, as has been mentioned in many studies, puts a large number of people off cycling for transport (For example Heinen*, et al.*, 2010; Kingham*, et al.*, 2011; Parkin*, et al.*, 2007; Pucher & Buehler, 2008b). While promoting recreational cycling may lead to an increase in commuter cycling, it seems clear that in order to achieve a large uptake of transport cycling this major barrier needs to be addressed by installing a network of segregated cycle ways (Buehler & Pucher, 2012; Dill, 2009; Kingham*, et al.*, 2011; Pucher & Buehler, 2008b).

Additionally, the literature notes that there are fewer women commuting by bicycle in cities that offer little support for transport cycling (Buehler & Pucher, 2012; Garrard*, et al.*, 2008; Moudon*, et al.*, 2005; Troped*, et al.*, 2001). This pattern has also been seen in the present study. The pattern is often attributed to the difference in risk aversion between men and women (Garrard*, et al.*, 2008), where women tend not to risk personal safety as much as men. In this study, recreational cyclists seem to be split much more evenly between the genders, suggesting that recreational cycling is just as attractive to women as it is to men. However, female recreational cyclists had significantly lower scores for all the commuter cycling behavioural antecedents, except commuter driving habit, than male recreational cyclists. Female recreational cyclists do still have higher scores for those variables than female non-cyclists, suggesting that recreational cycling promotion could help both men and women take up commuter cycling, but is unlikely to help address the gap between male and female commuter cycling numbers. To address this issue and increase the proportion of women commuting by bicycle, complementary policies would need to be combined with recreational cycling promotion to specifically target and encourage women. Comprehensive improvements in actual and perceived safety that make cycling feel more comfortable would also likely go a long way in addressing this gender imbalance (Garrard*, et al.*, 2008).

5.2 Strengths and limitations

This project has provided an opportunity to explore an interesting, significant and under-researched topic. Particular strengths and weaknesses of this research and its design have become apparent throughout this process.

5.2.1 Recruitment and sample

The recruitment method of encouraging people to forward the survey link to their contacts and offering a prize draw to incentivise participation resulted in a large sample size which provides strength to the results and conclusions drawn. However, these methods have also resulted in participants being self-selected, which has resulted in a bias toward cyclists and away from young adults. The online nature of the survey excluded those who did not have time to spend at a computer, but did provide easy access to a large proportion of the region's population.

If this study were to be repeated or extended it would be important to explore why Māori and Pasifika participation rates were so low and to try to rectify this problem. Low response could reflect the topic of the research, or the survey questions not appealing, or the recruitment method not being culturally appropriate.

While the study sample is not representative of the Wellington Region population, it does include a large number of people who are actively involved in the workforce and regularly commute in the region. The survey captures the views of those interested in commuter transport so does still provide valuable insights into commuting behaviour and perceptions of cycling in the Wellington Region.

5.2.2 Methodology and analysis

One of the strengths of this research is that it employed a mixed methods design. Combining both qualitative and quantitative methods has provided more depth to the results and insight into the nuances of the perceptions of contextual factors that either method alone would not have given.

Another strength is the high explanatory powers of the SEM and regression models, reflecting the strength of the theory chosen to explore this topic. The SEM provided a useful diagrammatic output that facilitates clear inferences being drawn and deals well with measurement error (Byrne, 2010). However, the departures from normality of the data (as discussed in Chapter 3) may have had unknown effects on the results.

The two significant limitations of this study are the lack of a broader measure of commuting habit and the lack of a more detailed empirical measure of the wider contextual factors that influence individuals' choice of commuter transport mode. It would have been beneficial to investigate the full range of commuter transport habits, not solely driving habit. Additionally, gathering more information on the context in which the individuals live may have further strengthened the model and this research. However, for the scope and scale of this research it was important to limit its complexity, in order to achieve a balance between parsimony and comprehensiveness. It was also important that the online survey was not too time consuming for participants, to ensure a high response and completion rate.

Finally, the criteria that were chosen to reduce the larger sample into the three subgroups will have influenced the results. Changing exactly how recreational cyclists are distinguished from commuter cyclists could alter the findings. However, it was necessary to pick a distinct boundary between the groups and this was done with careful consideration. An effort was made to choose the group formation criteria logically and clearly and to minimise skewing of the results. However, it must still be acknowledged that the groups could have been defined in a number of subtly different, but still valid, ways.

5.3 Further research

The present research has addressed an important research gap by exploring whether recreational cyclists are more amenable to commuting by bicycle than non-cyclists in the Wellington Region. There is, however, further work to be done in this area, primarily exploring whether these findings apply elsewhere in New Zealand and in other countries. As such, it would be interesting to apply the present research methodology to other cities, or alternatively test other theoretical behaviour models and new modes of enquiry to see if these findings stand.

As foreshadowed in Chapter 1, and having now established that recreational cyclists are more amenable to commuting by bicycle than non-cyclists, it would be valuable to test the effectiveness of promoting recreational cycling on utilitarian cycling through an applied recreational cycling policy intervention study that assessed pre- and post-intervention recreational and commuter cycling levels. Such studies should look at both the effectiveness of recreational cycling policies on non-cyclists as well as the effectiveness of commuter cycling policies on recreational cyclists. This would establish how effective the promotion of recreational cycling would be at encouraging commuter cycling.

It would also be valuable to further develop the proposed theoretical model used in this study by exploring ways to improve empirical measures for the context and habit factors.

5.4 Policy recommendations

As discussed at the beginning of this thesis, increasing the use of cycling for transport offers many benefits and is an important way of addressing a number of serious problems facing cities around the world. However, with the dominance of car travel and car orientated urban environments, cycling is unlikely to become a major mode of transport without the active support of policy. The literature that has been reviewed during the course of this project, and the results of this research have highlighted important areas that need to be addressed through policy, from which policy recommendations for the promotion of commuter cycling, or any transport cycling, can be drawn.

The most important policy recommendation to come out of this work is that a comprehensive suite of complementary policy options needs to be employed to successfully encourage cycling for transport at a large scale, as has been pointed out by a number of studies, including Pucher and Buehler (2008b) and Pucher*, et al.* (2010). This research suggests that the promotion of recreational cycling could be an important part of such a strategy.

To benefit transport cycling the most, recreational cycling policies should be designed to make recreational cycling appealing and accessible to a wide range of the population. This could be achieved through the support of existing recreational cycling clubs and organisations to promote fun cycling skills development, and the facilitation of events and races for all levels of cycling. This should be done with a particular focus on the under-represented groups in recreational and commuter cycling, specifically women, young people and those on lower incomes.

This could be accompanied with a broader cycling strategy that, in Wellington’s case, promotes the features of the region that are compatible with, or supportive of, cycling and emphasises the enjoyable, healthy and social aspects of cycling. Alongside this, it would be helpful to encourage a cultural shift in the attitudes and behaviours of all road users in their rights and responsibilities to each other.

The intervention that is likely to have the greatest effect on cycling numbers is the installation of infrastructure that makes cycling safe, practical and convenient. As Pucher and Buehler (2008b) recommend, this would include segregated cycle ways on busy roads and traffic calming on other routes, as well as encouraging public transport integration and the provision of parking, changing and showering facilities at workplaces and places of study (Kingham*, et al.*, 2011).

5.5 Conclusion

This study aimed to determine whether recreational cyclists are more amenable to commuting by bicycle than non-cyclists in the Wellington Region. To address this aim an empirical, individual behaviour model, developed from Ajzen's (1991) Theory of Planned Behaviour and the wider literature, was applied to commuter cycling behaviour. This extended model was found to have a strong explanatory power for commuter cycling behaviour, which provides support for the use, in this field of study, of the Theory of Planned Behaviour, adapted to include Triandis' (1977) Social Factors and a measure of habit, as suggested by Bamberg and Schmidt (2003). Perceived behavioural control was found to be of particular importance in explaining the intention to commute by bicycle, and therefore in explaining commuter cycling behaviour. The results showed that, for the research sample, recreational cyclists were closer to commuter cyclists than they were to non-cyclists for all modelled behavioural antecedents (specifically perceived behavioural control, attitude, social factors and intention), except for commuter driving habit.

An exploration of perceptions supported the empirical modelling by showing that recreational cyclists are more prepared and willing to commute by bicycle than non-cyclists. As such it can be suggested that for this study sample, at least, recreational cyclists are more amenable than non-cyclists to taking up commuter cycling. However, significant uptake of commuter cycling is strongly inhibited by a general perception that it is not safe to cycle with traffic on roads in the Wellington Region, due to the design of the roads and driver behaviour.

Therefore, we can conclude that recreational cyclists are indeed more amenable to commuting by bicycle than non-cyclists. This suggests that promoting recreational cycling could well increase commuter cycling levels, although further research is required. However, this strategy will not be effective in isolation. It appears that the promotion of recreational cycling would be a useful component of a broader, comprehensive and complementary cycling policy in the greater Wellington Region. This should particularly include strong policies to improve the road safety and comfort of utilitarian cyclists.

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Appendix A: Ethics Approval

TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI
VICTORIA
UNIVERSITY OF WELLINGTON

MEMORANDUM

Phone 0-4-463 5676
Fax 0-4-463 5209
Email Allison.kirkman@vuw.ac.nz

TO	Edward Randal
COPY TO	Ralph Chapman
FROM	Dr Allison Kirkman, Convener, Human Ethics Committee

DATE	17 December 2012
PAGES	1

SUBJECT	**Ethics Approval: 19534** **Promoting cycling in Wellington, New Zealand**

Thank you for your request to amend your ethics approval. This has now been considered and the request granted.

Your application has approval until 12 May 2013. If your data collection is not completed by this date you should apply to the Human Ethics Committee for an extension to this approval.

Best wishes with your research.

Allison Kirkman
Human Ethics Committee

Appendix B: Online Survey

Commuter Transport Survey

Participant consent

Please read the following consent information, then click on the button below to progress to the survey

Information for Promoting Cycling in Wellington, New Zealand Survey

Researcher: Ed Randal
Master of Environmental Studies Student
Telephone: 021 424 209
Email: ed.randal@vuw.ac.nz

Purpose of the study
The study will explore how effective the promotion of recreational cycling might be at increasing the number of people that commute by bicycle in Wellington. This research project has received ethics approval by the Victoria University of Wellington Human Ethics Committee.
This survey is designed to give an insight into the cycling habits of the Wellington public as well as their motivations, perceptions and attitudes towards cycling.

What is involved if you agree to participate?
You would fill out a short questionnaire in which you answer questions on how you get to work or school, your attitudes, perceptions, intentions and habits around cycling, and your basic demographics.
I anticipate that your involvement will take around 5 minutes.
You do not need to answer any particular questions if you do not wish to.

Privacy and Confidentiality
You will not be individually identified in my research project or in any other presentation or publication. The information you provide will be coded by number only.
A copy of the coded and anonymous data will remain in my custody for up to two years.
All written material will be stored in a locked file, and electronic material will be stored in a password protected file, with access restricted to me.

What happens to the information that you provide?
The results of this study may be submitted for publication in a scientific journal, presented at scientific conferences, or made available via the NZ Centre for Sustainable Cities website.
The results will form part of my Master's thesis that will be submitted for assessment and made publicly available in the Victoria University library and digitally on the Library website.

If you have any further questions regarding this study, or if you would like a summary of the results, please contact me or my supervisor via the contact details provided.

Thanks,
Ed Randal

Supervisor: Associate Professor Ralph Chapman
Email: ralph.chapman@vuw.ac.nz
School of Geography, Environment and Earth Sciences (SGEES)
Victoria University of Wellington
PO Box 600
Wellington 6140
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❍ I confirm that I have read and understood the information above. I wish to continue with the survey. (4)

Q2 Do you live in the Wellington Region?

❍ Yes (1)
❍ No (2)

If No Is Selected, Then Skip To End of Survey

Q3 Are you in the paid workforce?

❍ Yes (1)
❍ No (2)

Q4 Are you currently studying?

❍ Yes (1)
❍ No (2)

Q5 Do you regularly commute for either of these purposes?

❍ Yes (1)
❍ No (2)

If No Is Selected, Then Skip To End of Survey

Q6 Do you have access to a bike that is suitable for commuting?

❍ Yes (1)
❍ No (2)

Q7 Do you have access to a bike that is suitable for recreational riding?

❍ Yes (1)
❍ No (2)

Q8 Do you have access to a car?

❍ Yes (1)
❍ No (2)

Q9 Do you have a permanent or long-term physical condition that prevents you from cycling?

- ❍ Yes (1)
- ❍ No (2)

Q10 In the last 12 months have you ridden a bicycle at all?

- ❍ Yes (1)
- ❍ No (2)

Q11 On average how many days do you commute by bicycle?

- ❍ Never (1)
- ❍ Less than 1 per month (2)
- ❍ 1-3 per month (3)
- ❍ 1-2 per week (4)
- ❍ 3+ per week (5)

If Never Is Selected, Then Skip To Q13

Q12 If you do commute by bicycle...

...why do you choose this mode of transport? (1)
...how far do you estimate you commute by bike per trip? (2)

Q13 On average how many times do you cycle for recreation (any cycling not for transport)?

- ❍ Never (1)
- ❍ Less than 1 per month (2)
- ❍ 1-3 per month (3)
- ❍ 1-2 per week (4)
- ❍ 3+ per week (5)

If Never Is Selected, Then Skip To Q15

Q14 If you do cycle for recreation, why do you choose to do this?

Q15 When you were young, did you regularly cycle to primary school or high school?

- ❍ Yes (1)
- ❍ No (2)

Q16 Please click the number on the scales below that best indicates how much you agree with the following statement.

	Agree 1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	Disagree 7 (7)
I like to, or would like to cycle to work or study. (1)	❍	❍	❍	❍	❍	❍	❍

Q17 Please click the points on the scale below that best matches how you feel about cycling. In your opinion, cycling as a means of transport is:

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)
Good : Bad (1)	❍	❍	❍	❍	❍	❍	❍
Enjoyable : Unpleasant (2)	❍	❍	❍	❍	❍	❍	❍
Sensible : Not sensible (3)	❍	❍	❍	❍	❍	❍	❍
Convenient : Inconvenient (4)	❍	❍	❍	❍	❍	❍	❍
Realistic : Unrealistic (5)	❍	❍	❍	❍	❍	❍	❍
Safe : Unsafe (6)	❍	❍	❍	❍	❍	❍	❍

Q18 Please select the point on the scales below that best indicates how much you agree with the following statements.   If you do not know, just leave your answer blank.

	Agree 1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	Disagree 7 (7)
Most people like me commute by bicycle. (1)	❍	❍	❍	❍	❍	❍	❍
Most people who are important to me commute by bicycle. (2)	❍	❍	❍	❍	❍	❍	❍
Most people who are important to me would approve of me commuting by bicycle. (3)	❍	❍	❍	❍	❍	❍	❍
It would be impossible for me to commute by bicycle. (5)	❍	❍	❍	❍	❍	❍	❍
I am sure that in the next few days I can cycle to work or study. (6)	❍	❍	❍	❍	❍	❍	❍
It is mostly up to me whether I use a bicycle rather than a car to get to work or study. (7)	❍	❍	❍	❍	❍	❍	❍
I do not feel capable of cycling to work or study. (8)	❍	❍	❍	❍	❍	❍	❍

Answer If Do you work? Yes Is Selected

Q19 How do you usually get to work?

- Car (1)
- Bike (2)
- Walk (3)
- Public transport (4)
- Other (5)
- N/A (6)

Answer If Are you currently studying? Yes Is Selected

Q20 How do you usually get to your place of study?

- Car (1)
- Bike (2)
- Walk (3)
- Public transport (4)
- Other (5)
- N/A (6)

Q21 Please select the point on the scales below that best indicates how much you agree with the following statements.

	Agree 1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	Disagree 7 (7)
I often drive to get to work or study. (1)	❍	❍	❍	❍	❍	❍	❍
It would make me feel strange if I did not drive to work or study. (2)	❍	❍	❍	❍	❍	❍	❍
Driving to work or study belongs to my daily or weekly routine. (3)	❍	❍	❍	❍	❍	❍	❍
Cycling to work or study is something that is typically me. (4)	❍	❍	❍	❍	❍	❍	❍
Cycling to work or study belongs to my daily or weekly routine. (5)	❍	❍	❍	❍	❍	❍	❍
I have not cycled to work or study for a long time. (6)	❍	❍	❍	❍	❍	❍	❍

Q22 Please select the point on the scales below that best indicates your response to the following statement.

	Very likely 1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	Very unlikely 7 (7)
How likely is it that you will commute by bicycle in the next few weeks? (Or after returning from the Christmas break) (1)	❍	❍	❍	❍	❍	❍	❍

Q23 What are the barriers to you cycling (or cycling more often) to work or study?

Q24 What, if anything, would encourage you to cycle (more regularly) to work or study?

Q25 Please indicate your age:

- ❍ Under 18 (1)
- ❍ 18-19 (2)
- ❍ 20-29 (3)
- ❍ 30-39 (4)
- ❍ 40-49 (5)
- ❍ 50-59 (6)
- ❍ 60+ (7)

Q26 Please indicate your gender:

- Male (1)
- Female (2)

Q27 Which suburb do you live in? Please type below

Q28 Please indicate your annual level of income before tax:

- $0 (1)
- $1-$25,000 (2)
- $25,001-$50,000 (3)
- $50,001-$100,000 (4)
- $100,001+ (5)

Q29 Please indicate your highest level of education:

- No Qualification (1)
- High School Qualification (2)
- Tertiary Degree (3)
- Tertiary Other (4)

Q30 Please indicate your ethnicity:

- European (1)
- Māori (2)
- Pacific Peoples (3)
- Asian (4)
- Other (5)

Appendix C: Missing Values Treatment Comparison

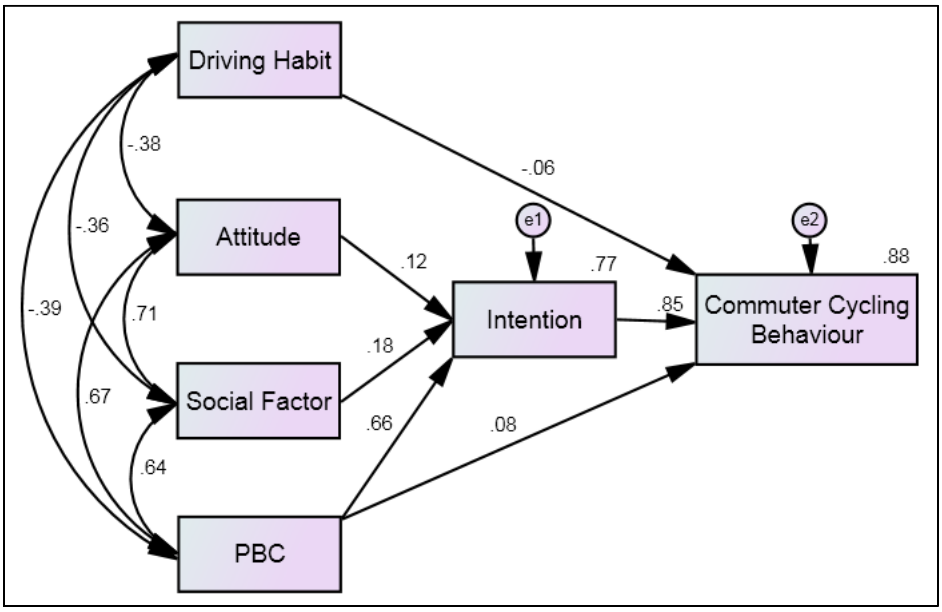
Listwise Deletion

Descriptives

			Statistic	Std. Error
Attitude	Mean		5.11089	.054827
	95% Confidence Interval for Mean	Lower Bound	5.00322	
		Upper Bound	5.21855	
	5% Trimmed Mean		5.19195	
	Median		5.42857	
	Variance		1.921	
	Std. Deviation		1.385940	
	Minimum		1.000	
	Maximum		7.000	
	Range		6.000	
	Interquartile Range		2.000	
	Skewness		-.746	.097
	Kurtosis		-.152	.193
Social Factor	Mean		3.56142	.057369
	95% Confidence Interval for Mean	Lower Bound	3.44877	
		Upper Bound	3.67408	
	5% Trimmed Mean		3.55477	
	Median		3.75000	
	Variance		2.103	
	Std. Deviation		1.450206	
	Minimum		1.000	
	Maximum		7.000	
	Range		6.000	
	Interquartile Range		2.000	
	Skewness		-.031	.097
	Kurtosis		-.836	.193
PBC	Mean		4.70944	.086181
	95% Confidence Interval for Mean	Lower Bound	4.54021	
		Upper Bound	4.87868	
	5% Trimmed Mean		4.78827	
	Median		5.00000	
	Variance		4.746	
	Std. Deviation		2.178529	
	Minimum		1.000	
	Maximum		7.000	
	Range		6.000	
	Interquartile Range		4.000	
	Skewness		-.345	.097
	Kurtosis		-1.371	.193
Driving Habit	Mean		2.68466	.088841
	95% Confidence Interval for Mean	Lower Bound	2.51021	
		Upper Bound	2.85912	
	5% Trimmed Mean		2.53852	
	Median		1.50000	
	Variance		5.043	
	Std. Deviation		2.245759	
	Minimum		1.000	
	Maximum		7.000	
	Range		6.000	
	Interquartile Range		3.500	
	Skewness		.995	.097
	Kurtosis		-.655	.193

Descriptives continued

			Statistic	Std. Error
Commuter Cycling Behaviour	Mean		3.46062	.101221
	95% Confidence Interval for Mean	Lower Bound	3.26185	
		Upper Bound	3.65938	
	5% Trimmed Mean		3.40068	
	Median		2.00000	
	Variance		6.547	
	Std. Deviation		2.558709	
	Minimum		1.000	
	Maximum		7.000	
	Range		6.000	
	Interquartile Range		5.667	
	Skewness		.404	.097
	Kurtosis		-1.653	.193
Intention	Mean		3.6761	.11257
	95% Confidence Interval for Mean	Lower Bound	3.4550	
		Upper Bound	3.8971	
	5% Trimmed Mean		3.6401	
	Median		2.0000	
	Variance		8.097	
	Std. Deviation		2.84554	
	Minimum		1.00	
	Maximum		7.00	
	Range		6.00	
	Interquartile Range		6.00	
	Skewness		.224	.097
	Kurtosis		-1.878	.193



Measure	Value
N	639
χ^2	25.136
Degrees of freedom (df)	3
χ^2/df	8.379
GFI (>0.950)	0.987
CFI (>0.900)	0.993
TLI (>0.900)	0.967
RMSEA (≤0.08)	0.108

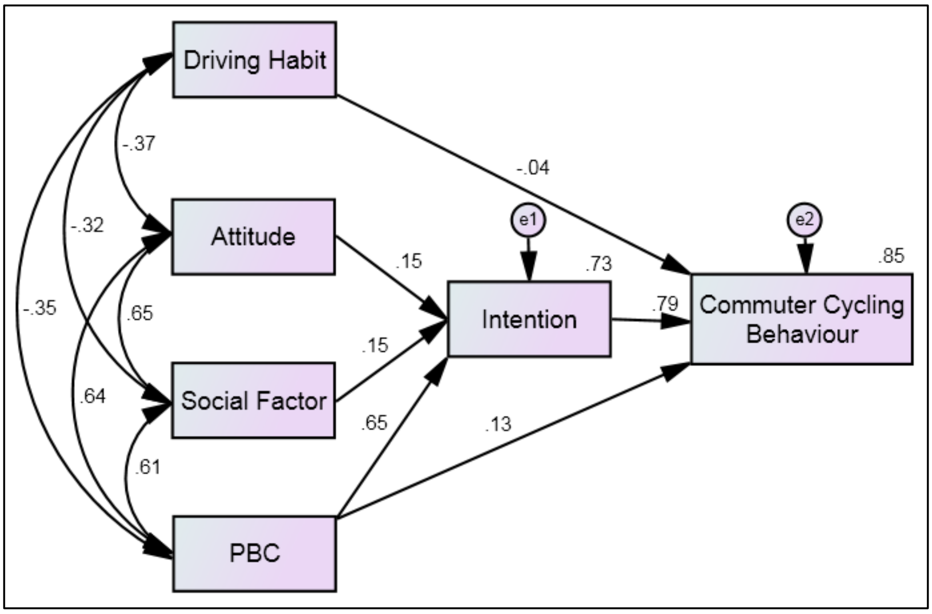
Mean Replacement

Descriptives

			Statistic	Std. Error
Attitude	Mean		5.071636	.0480910
	95% Confidence Interval for Mean	Lower Bound	4.977232	
		Upper Bound	5.166040	
	5% Trimmed Mean		5.146026	
	Median		5.285714	
	Variance		1.799	
	Std. Deviation		1.3413848	
	Minimum		1.0000	
	Maximum		7.0000	
	Range		6.0000	
	Interquartile Range		1.8571	
	Skewness		-.721	.088
	Kurtosis		-.052	.175
Social Factor	Mean		3.548072	.0500832
	95% Confidence Interval for Mean	Lower Bound	3.449758	
		Upper Bound	3.646386	
	5% Trimmed Mean		3.538025	
	Median		3.550000	
	Variance		1.951	
	Std. Deviation		1.3969525	
	Minimum		1.0000	
	Maximum		7.0000	
	Range		6.0000	
	Interquartile Range		2.0000	
	Skewness		-.002	.088
	Kurtosis		-.578	.175
PBC	Mean		4.624473	.0763950
	95% Confidence Interval for Mean	Lower Bound	4.474508	
		Upper Bound	4.774438	
	5% Trimmed Mean		4.693859	
	Median		4.666667	
	Variance		4.541	
	Std. Deviation		2.1308598	
	Minimum		1.0000	
	Maximum		7.0000	
	Range		6.0000	
	Interquartile Range		4.0000	
	Skewness		-.286	.088
	Kurtosis		-1.326	.175
Driving Habit	Mean		2.698972	.0812569
	95% Confidence Interval for Mean	Lower Bound	2.539463	
		Upper Bound	2.858481	
	5% Trimmed Mean		2.554413	
	Median		1.500000	
	Variance		5.137	
	Std. Deviation		2.2664696	
	Minimum		1.0000	
	Maximum		7.0000	
	Range		6.0000	
	Interquartile Range		3.5000	
	Skewness		.979	.088
	Kurtosis		-.704	.175

Descriptives continued

			Statistic	Std. Error
Commuter Cycling Behaviour	Mean		3.327704	.0897324
	95% Confidence Interval for Mean	Lower Bound	3.151557	
		Upper Bound	3.503850	
	5% Trimmed Mean		3.253004	
	Median		2.000000	
	Variance		6.264	
	Std. Deviation		2.5028735	
	Minimum		1.0000	
	Maximum		7.0000	
	Range		6.0000	
	Interquartile Range		5.3333	
	Skewness		.505	.088
	Kurtosis		-1.528	.175
Intention	Mean		3.512275	.1008735
	95% Confidence Interval for Mean	Lower Bound	3.314258	
		Upper Bound	3.710292	
	5% Trimmed Mean		3.458083	
	Median		1.000000	
	Variance		7.917	
	Std. Deviation		2.8136305	
	Minimum		1.0000	
	Maximum		7.0000	
	Range		6.0000	
	Interquartile Range		6.0000	
	Skewness		.335	.088
	Kurtosis		-1.807	.175



Measure	Value
N	778
χ^2	32.966
Degrees of freedom (df)	3
χ^2/df	10.989
GFI (>0.950)	0.986
CFI (>0.900)	0.992
TLI (>0.900)	0.958
RMSEA (≤0.08)	0.113

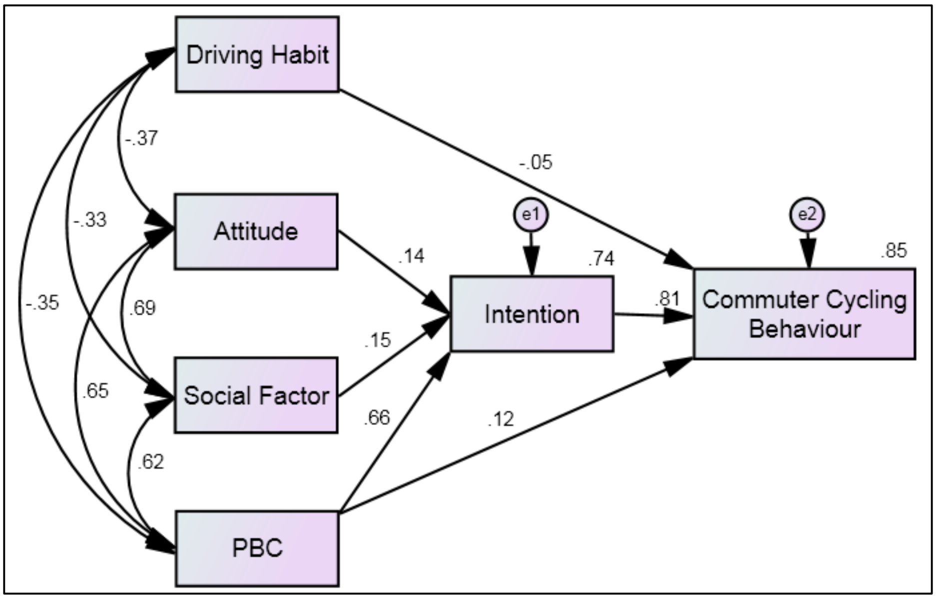
Neutral Value Replacement

Descriptives

			Statistic	Std. Error
Attitude	Mean		5.04737	.049087
	95% Confidence Interval for Mean	Lower Bound	4.95102	
		Upper Bound	5.14373	
	5% Trimmed Mean		5.12007	
	Median		5.28571	
	Variance		1.875	
	Std. Deviation		1.369168	
	Minimum		1.000	
	Maximum		7.000	
	Range		6.000	
	Interquartile Range		2.000	
	Skewness		-.676	.088
	Kurtosis		-.239	.175
Social Factor	Mean		3.57166	.051739
	95% Confidence Interval for Mean	Lower Bound	3.47009	
		Upper Bound	3.67322	
	5% Trimmed Mean		3.56284	
	Median		3.75000	
	Variance		2.083	
	Std. Deviation		1.443127	
	Minimum		1.000	
	Maximum		7.000	
	Range		6.000	
	Interquartile Range		2.000	
	Skewness		-.022	.088
	Kurtosis		-.774	.175
Perceived Behavioural Control	Mean		4.59897	.076965
	95% Confidence Interval for Mean	Lower Bound	4.44789	
		Upper Bound	4.75006	
	5% Trimmed Mean		4.66552	
	Median		4.66667	
	Variance		4.609	
	Std. Deviation		2.146764	
	Minimum		1.000	
	Maximum		7.000	
	Range		6.000	
	Interquartile Range		4.000	
	Skewness		-.254	.088
	Kurtosis		-1.376	.175
Driving Habit	Mean		2.70437	.081314
	95% Confidence Interval for Mean	Lower Bound	2.54475	
		Upper Bound	2.86399	
	5% Trimmed Mean		2.56041	
	Median		1.50000	
	Variance		5.144	
	Std. Deviation		2.268072	
	Minimum		1.000	
	Maximum		7.000	
	Range		6.000	
	Interquartile Range		3.500	
	Skewness		.970	.088
	Kurtosis		-.719	.175

Descriptives continued

			Statistic	Std. Error
Commuter Cycling Behaviour	Mean		3.32134	.089878
	95% Confidence Interval for Mean	Lower Bound	3.14490	
		Upper Bound	3.49777	
	5% Trimmed Mean		3.24593	
	Median		2.00000	
	Variance		6.285	
	Std. Deviation		2.506933	
	Minimum		1.000	
	Maximum		7.000	
	Range		6.000	
	Interquartile Range		5.333	
	Skewness		.511	.088
	Kurtosis		-1.531	.175
Intention	Mean		3.5154	.10088
	95% Confidence Interval for Mean	Lower Bound	3.3174	
		Upper Bound	3.7135	
	5% Trimmed Mean		3.4616	
	Median		1.0000	
	Variance		7.918	
	Std. Deviation		2.81390	
	Minimum		1.00	
	Maximum		7.00	
	Range		6.00	
	Interquartile Range		6.00	
	Skewness		.331	.088
	Kurtosis		-1.809	.175



Measure	Value
N	778
χ^2	37.551
Degrees of freedom (df)	3
χ^2/df	12.517
GFI (>0.950)	0.985
CFI (>0.900)	0.991
TLI (>0.900)	0.953
RMSEA (≤0.08)	0.122

Appendix D: Normality Tests of Constructs

Descriptives

			Statistic	Std. Error
Attitude	Mean		5.04737	.049087
	95% Confidence Interval for Mean	Lower Bound	4.95102	
		Upper Bound	5.14373	
	5% Trimmed Mean		5.12007	
	Median		5.28571	
	Variance		1.875	
	Std. Deviation		1.369168	
	Minimum		1.000	
	Maximum		7.000	
	Range		6.000	
	Interquartile Range		2.000	
	Skewness		-.676	.088
	Kurtosis		-.239	.175
Social Factor	Mean		3.57166	.051739
	95% Confidence Interval for Mean	Lower Bound	3.47009	
		Upper Bound	3.67322	
	5% Trimmed Mean		3.56284	
	Median		3.75000	
	Variance		2.083	
	Std. Deviation		1.443127	
	Minimum		1.000	
	Maximum		7.000	
	Range		6.000	
	Interquartile Range		2.000	
	Skewness		-.022	.088
	Kurtosis		-.774	.175
Perceived Behavioural Control	Mean		4.59897	.076965
	95% Confidence Interval for Mean	Lower Bound	4.44789	
		Upper Bound	4.75006	
	5% Trimmed Mean		4.66552	
	Median		4.66667	
	Variance		4.609	
	Std. Deviation		2.146764	
	Minimum		1.000	
	Maximum		7.000	
	Range		6.000	
	Interquartile Range		4.000	
	Skewness		-.254	.088
	Kurtosis		-1.376	.175
Driving Habit	Mean		2.70437	.081314
	95% Confidence Interval for Mean	Lower Bound	2.54475	
		Upper Bound	2.86399	
	5% Trimmed Mean		2.56041	
	Median		1.50000	
	Variance		5.144	
	Std. Deviation		2.268072	
	Minimum		1.000	
	Maximum		7.000	
	Range		6.000	
	Interquartile Range		3.500	
	Skewness		.970	.088
	Kurtosis		-.719	.175

Descriptives continued

			Statistic	Std. Error
Commuter Cycling Behaviour	Mean		3.32134	.089878
	95% Confidence Interval for Mean	Lower Bound	3.14490	
		Upper Bound	3.49777	
	5% Trimmed Mean		3.24593	
	Median		2.00000	
	Variance		6.285	
	Std. Deviation		2.506933	
	Minimum		1.000	
	Maximum		7.000	
	Range		6.000	
	Interquartile Range		5.333	
	Skewness		.511	.088
	Kurtosis		-1.531	.175
Intention	Mean		3.5154	.10088
	95% Confidence Interval for Mean	Lower Bound	3.3174	
		Upper Bound	3.7135	
	5% Trimmed Mean		3.4616	
	Median		1.0000	
	Variance		7.918	
	Std. Deviation		2.81390	
	Minimum		1.00	
	Maximum		7.00	
	Range		6.00	
	Interquartile Range		6.00	
	Skewness		.331	.088
	Kurtosis		-1.809	.175

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Attitude	.097	778	.000	.946	778	.000
Social Factor	.074	778	.000	.977	778	.000
Perceived Behavioural Control	.184	778	.000	.873	778	.000
Driving Habit	.278	778	.000	.725	778	.000
Commuter Cycling Behaviour	.236	778	.000	.765	778	.000
Intention	.327	778	.000	.687	778	.000

a. Lilliefors Significance Correction

Appendix E: χ^2 Tables of Statistically Significant Associations

Comparisons of Characteristics between Cycling Groups

Age

Crosstab

			Age (reduced)					Total
			18 - 29	30 - 39	40 - 49	50 - 59	60+	
Cycling Group	Non Cyclist	Count	114	89	77	79	32	391
		Std. Residual	2.6	-1.0	-2.6	.6	1.4	
	Recreational Cyclist	Count	27	40	58	28	9	162
		Std. Residual	-1.7	-.2	2.3	-.5	-.4	
	Commuter Cyclist	Count	37	68	70	40	9	224
		Std. Residual	-2.0	1.5	1.4	-.4	-1.4	
Total		Count	178	197	205	147	50	777

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	35.569[a]	8	.000
Likelihood Ratio	35.823	8	.000
Linear-by-Linear Association	.693	1	.405
N of Valid Cases	777		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 10.42.

Gender

Crosstab

			Gender		Total
			Male	Female	
Cycling Group	Non Cyclist	Count	129	260	389
		Std. Residual	-3.3	2.9	
	Recreational Cyclist	Count	83	78	161
		Std. Residual	1.4	-1.3	
	Commuter Cyclist	Count	129	94	223
		Std. Residual	3.1	-2.7	
Total		Count	341	432	773

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	39.600[a]	2	.000
Likelihood Ratio	39.923	2	.000
Linear-by-Linear Association	37.691	1	.000
N of Valid Cases	773		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 71.02.

Income

Crosstab

			Income (Reduced)				Total
			$0-$25,000	$25,001-$50,000	$50,001-$100,000	$100,001+	
Cycling Group	Non Cyclist	Count	63	77	181	56	377
		Std. Residual	1.8	2.9	-.8	-2.6	
	Recreational Cyclist	Count	17	15	84	45	161
		Std. Residual	-1.0	-1.8	.2	1.9	
	Commuter Cyclist	Count	21	19	122	59	221
		Std. Residual	-1.6	-2.3	.9	1.8	
Total		Count	101	111	387	160	759

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	39.178[a]	6	.000
Likelihood Ratio	39.932	6	.000
Linear-by-Linear Association	26.811	1	.000
N of Valid Cases	759		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 21.42.

Appendix F: ANOVA Tables of Gender Comparisons

ANOVA

Gender			Sum of Squares	df	Mean Square	F	Sig.
Male	Attitude	Between Groups	231.692	2	115.846	116.915	.000
		Within Groups	334.909	338	.991		
		Total	566.601	340			
	Social Factor	Between Groups	212.933	2	106.466	84.864	.000
		Within Groups	424.039	338	1.255		
		Total	636.972	340			
	Perceived Behavioural Control	Between Groups	747.385	2	373.692	240.442	.000
		Within Groups	525.317	338	1.554		
		Total	1272.701	340			
	Driving Habit	Between Groups	162.661	2	81.331	19.750	.000
		Within Groups	1391.877	338	4.118		
		Total	1554.538	340			
	Intention	Between Groups	2106.235	2	1053.117	544.658	.000
		Within Groups	653.536	338	1.934		
		Total	2759.771	340			
	Commuter Cycling Behaviour	Between Groups	1752.157	2	876.078	608.611	.000
		Within Groups	486.541	338	1.439		
		Total	2238.698	340			
Female	Attitude	Between Groups	288.743	2	144.371	112.490	.000
		Within Groups	550.584	429	1.283		
		Total	839.327	431			
	Social Factor	Between Groups	266.209	2	133.105	86.281	.000
		Within Groups	661.809	429	1.543		
		Total	928.019	431			
	Perceived Behavioural Control	Between Groups	1041.836	2	520.918	238.147	.000
		Within Groups	938.386	429	2.187		
		Total	1980.222	431			
	Driving Habit	Between Groups	228.058	2	114.029	22.842	.000
		Within Groups	2141.571	429	4.992		
		Total	2369.630	431			
	Intention	Between Groups	2156.866	2	1078.433	591.157	.000
		Within Groups	782.614	429	1.824		
		Total	2939.479	431			
	Commuter Cycling Behaviour	Between Groups	1826.324	2	913.162	880.051	.000
		Within Groups	445.141	429	1.038		
		Total	2271.465	431			

Multiple Comparisons

Tukey HSD

Gender	Dependent Variable	(I) Cycling Group	(J) Cycling Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Male	Attitude	Non Cyclist	Recreational Cyclist	-1.316922*	.140068	.000	-1.64665	-.98719
			Commuter Cyclist	-1.856035*	.123944	.000	-2.14781	-1.56426
		Recreational Cyclist	Non Cyclist	1.316922*	.140068	.000	.98719	1.64665
			Commuter Cyclist	-.539113*	.140068	.000	-.86885	-.20938
		Commuter Cyclist	Non Cyclist	1.856035*	.123944	.000	1.56426	2.14781
			Recreational Cyclist	.539113*	.140068	.000	.20938	.86885
	Social Factor	Non Cyclist	Recreational Cyclist	-1.303260*	.157608	.000	-1.67428	-.93224
			Commuter Cyclist	-1.769380*	.139465	.000	-2.09769	-1.44107
		Recreational Cyclist	Non Cyclist	1.303260*	.157608	.000	.93224	1.67428
			Commuter Cyclist	-.466120*	.157608	.009	-.83714	-.09510
		Commuter Cyclist	Non Cyclist	1.769380*	.139465	.000	1.44107	2.09769
			Recreational Cyclist	.466120*	.157608	.009	.09510	.83714
	Perceived Behavioural Control	Non Cyclist	Recreational Cyclist	-2.318577*	.175423	.000	-2.73154	-1.90562
			Commuter Cyclist	-3.343669*	.155229	.000	-3.70909	-2.97825
		Recreational Cyclist	Non Cyclist	2.318577*	.175423	.000	1.90562	2.73154
			Commuter Cyclist	-1.025093*	.175423	.000	-1.43805	-.61213
		Commuter Cyclist	Non Cyclist	3.343669*	.155229	.000	2.97825	3.70909
			Recreational Cyclist	1.025093*	.175423	.000	.61213	1.43805
	Driving Habit	Non Cyclist	Recreational Cyclist	.005651	.285546	1.000	-.66655	.67785
			Commuter Cyclist	1.426357*	.252675	.000	.83154	2.02118
		Recreational Cyclist	Non Cyclist	-.005651	.285546	1.000	-.67785	.66655
			Commuter Cyclist	1.420706*	.285546	.000	.74851	2.09291
		Commuter Cyclist	Non Cyclist	-1.426357*	.252675	.000	-2.02118	-.83154
			Recreational Cyclist	-1.420706*	.285546	.000	-2.09291	-.74851
	Intention	Non Cyclist	Recreational Cyclist	-3.85776*	.19566	.000	-4.3184	-3.3971
			Commuter Cyclist	-5.62016*	.17314	.000	-6.0277	-5.2126
		Recreational Cyclist	Non Cyclist	3.85776*	.19566	.000	3.3971	4.3184
			Commuter Cyclist	-1.76240*	.19566	.000	-2.2230	-1.3018
		Commuter Cyclist	Non Cyclist	5.62016*	.17314	.000	5.2126	6.0277
			Recreational Cyclist	1.76240*	.19566	.000	1.3018	2.2230
	Commuter Cycling Behaviour	Non Cyclist	Recreational Cyclist	-3.143987*	.168825	.000	-3.54141	-2.74656
			Commuter Cyclist	-5.183463*	.149390	.000	-5.53514	-4.83179
		Recreational Cyclist	Non Cyclist	3.143987*	.168825	.000	2.74656	3.54141
			Commuter Cyclist	-2.039476*	.168825	.000	-2.43690	-1.64205
		Commuter Cyclist	Non Cyclist	5.183463*	.149390	.000	4.83179	5.53514
			Recreational Cyclist	2.039476*	.168825	.000	1.64205	2.43690

Multiple Comparisons Continued

Tukey HSD

Gender	Dependent Variable	(I) Cycling Group	(J) Cycling Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Female	Attitude	Non Cyclist	Recreational Cyclist	-.940842*	.146254	.000	-1.28481	-.59687
			Commuter Cyclist	-2.007049*	.136343	.000	-2.32771	-1.68639
		Recreational Cyclist	Non Cyclist	.940842*	.146254	.000	.59687	1.28481
			Commuter Cyclist	-1.066207*	.173515	.000	-1.47429	-.65812
		Commuter Cyclist	Non Cyclist	2.007049*	.136343	.000	1.68639	2.32771
			Recreational Cyclist	1.066207*	.173515	.000	.65812	1.47429
	Social Factor	Non Cyclist	Recreational Cyclist	-.772436*	.160348	.000	-1.14955	-.39532
			Commuter Cyclist	-1.948241*	.149482	.000	-2.29980	-1.59668
		Recreational Cyclist	Non Cyclist	.772436*	.160348	.000	.39532	1.14955
			Commuter Cyclist	-1.175805*	.190235	.000	-1.62321	-.72840
		Commuter Cyclist	Non Cyclist	1.948241*	.149482	.000	1.59668	2.29980
			Recreational Cyclist	1.175805*	.190235	.000	.72840	1.62321
	Perceived Behavioural Control	Non Cyclist	Recreational Cyclist	-1.509402*	.190935	.000	-1.95846	-1.06035
			Commuter Cyclist	-3.856465*	.177997	.000	-4.27509	-3.43784
		Recreational Cyclist	Non Cyclist	1.509402*	.190935	.000	1.06035	1.95846
			Commuter Cyclist	-2.347063*	.226524	.000	-2.87982	-1.81431
		Commuter Cyclist	Non Cyclist	3.856465*	.177997	.000	3.43784	4.27509
			Recreational Cyclist	2.347063*	.226524	.000	1.81431	2.87982
	Driving Habit	Non Cyclist	Recreational Cyclist	.052564	.288444	.982	-.62582	.73095
			Commuter Cyclist	1.772422*	.268899	.000	1.14001	2.40484
		Recreational Cyclist	Non Cyclist	-.052564	.288444	.982	-.73095	.62582
			Commuter Cyclist	1.719858*	.342208	.000	.91503	2.52469
		Commuter Cyclist	Non Cyclist	-1.772422*	.268899	.000	-2.40484	-1.14001
			Recreational Cyclist	-1.719858*	.342208	.000	-2.52469	-.91503
	Intention	Non Cyclist	Recreational Cyclist	-2.04487*	.17437	.000	-2.4550	-1.6348
			Commuter Cyclist	-5.56260*	.16255	.000	-5.9449	-5.1803
		Recreational Cyclist	Non Cyclist	2.04487*	.17437	.000	1.6348	2.4550
			Commuter Cyclist	-3.51773*	.20687	.000	-4.0043	-3.0312
		Commuter Cyclist	Non Cyclist	5.56260*	.16255	.000	5.1803	5.9449
			Recreational Cyclist	3.51773*	.20687	.000	3.0312	4.0043
	Commuter Cycling Behaviour	Non Cyclist	Recreational Cyclist	-1.643162*	.131506	.000	-1.95245	-1.33388
			Commuter Cyclist	-5.136252*	.122595	.000	-5.42458	-4.84792
		Recreational Cyclist	Non Cyclist	1.643162*	.131506	.000	1.33388	1.95245
			Commuter Cyclist	-3.493090*	.156017	.000	-3.86002	-3.12616
		Commuter Cyclist	Non Cyclist	5.136252*	.122595	.000	4.84792	5.42458
			Recreational Cyclist	3.493090*	.156017	.000	3.12616	3.86002

*. The mean difference is significant at the 0.05 level.