CYCLING TO WORK: AN INTEGRATED APPROACH TO HUMAN DECISION MAKING

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Abstract

In this study, I explored human decision making from three perspectives – the theory of planned behaviour, the affect heuristic and an embodied perspective. One hundred and forty six participants were recruited in Christchurch city in New Zealand and their commuting habits were investigated. The focus of this study was the choice to commute by bicycle or not. In this study, the participants were assessed for their environmental beliefs or attitudes regarding cycling commuting, their affective reactions to cycling, their risk perception of cycling, their level of support of pro-cycling governmental policies, whether they commuted by bicycle or not, and a physiological measure that is indicative of exposure to foetal testosterone, the second to fourth digit ratio on their hands (2D:4D). The results of a regression analysis revealed that environmental attitude is predictive of the level of support for pro-cycling policies, in line with expectations from the theory of planned behaviour. A regression analysis revealed that affective reactions to cycling, 2D:4D and sex are predictive of risk perception of road cycling, in line with expectations based on the embodied and affect heuristic perspective. In addition, a logistic regression revealed that environmental attitudes, 2D:4D and sex are predictive of bicycle commuting behaviour. These findings suggest a composite decision making model that combines the theory of planned behaviour, the affect heuristic and embodiment may prove useful in understanding environmental decision making. In addition, the findings indicate the importance of embodiment in human decision making.

Introduction

The emission of greenhouse gas is becoming a serious environmental issue. For example, in developed nations like Canada, the transportation sector contributes approximately twenty-six percent of greenhouse gas emissions (Ngo, West & Calkins, 2009). One of the most environmentally significant decisions individuals have to make is their transport choice for commuting (Collins & Chambers, 2005).

Encouraging people to use bicycles as their means of daily commuting would improve local air quality; reduces greenhouse gas emissions, reduces the nation's dependence on imported petrol/oil and, perhaps, even ease the burden of health care services in the long term, given the rising global epidemic of obesity and related health problems (Wooliscroft & Ganglmair, 2009; Wen & Rissel, 2008). Governments of many countries attempt to promote cycling in order to ease their existing traffic as well as environmental problems (e.g. Doolittle, & Porter, 1994; Foster, 2001; Martens, 2007).

Christchurch, New Zealand is an ideal location for the use of bicycles for transportation. The geography within the city proper is relatively flat with a relatively mild climate (temperature ranging from a 'Mean Daily Minimum' of 1.9°C in the winter to a 'Mean Daily Maximum' of 22.5°C in the summer) (University of Canterbury Liaison Office, n.d.). However, according to the nationwide marketing survey done by Wooliscroft and Ganglmair (2009), the number of bicycle commuters in New Zealand is low, despite the fact that there are around a million bicycles in households in New Zealand. Wooliscroft and Ganglmair (2009) suggest that other drivers' behaviour could be the major factor in preventing people from using bicycles, e.g. perceptions of road safety. Little research has, however, been conducted in New Zealand to determine the underlying psychological factors influencing the decision to use a bicycle for daily transportation.

The present study represents an initial attempt to explore multiple decision making models in the context of the choice to commute by bicycle in Christchurch, NZ. There are three different perspectives of behavioural choice models that will be explored: the theory of planned behaviour, the affect

heuristic, and embodied decision making perspectives. These different perspectives were explored in a convenience sample in Christchurch. Our fundamental question is whether aspects of the different decision making perspectives could, when combined, explain whether someone choose to commute or not by bicycle.

Decision making perspectives

In the current study, pro-environmental behaviours are regarded as the actions to be taken after certain pro-environmental decisions were made. Various behaviour modification and decision making models will be discussed.

Theory of Planned Behaviour

There are studies about pro-environmental behaviour and decision making that include cycling (e.g. Collins & Chambers, 2005; Monroe, 2003). Many pro-environmental behaviour researchers borrow existing psychological theories while others attempt to develop models specific to pro-environmental behaviours (Kollmuss, & Agyeman, 2002). According to the review done by Kollmuss and Agyeman (2002), none of the reviewed models are able to give a definitive explanation to the gap between pro-environmental beliefs and attitudes (including pro-environmental knowledge and awareness) and actual pro-environmental behaviours.

The theory of planned behaviour (TPB) is a relatively popular theory among the behavioural choice models (Ajzen, 1991). In the TPB, a person's behaviour is guided by three belief structures: behavioural beliefs, normative beliefs, and control beliefs. The behavioural beliefs reflect the person's individual attitude toward the behaviour (how they have assessed the behaviour's positive or negative value). The normative belief is based on the person's perceived social norms (what do others do and what is expected of the person). The control beliefs are the person's assessments of whether they actually have volitional control over the behaviour. The latter should not be confused with actual volitional control, but is an assessment of perceived control. These beliefs themselves influence or cause the person's behavioural intent and this in turn results in behavioural action. While not excluded explicitly

in the model, the TPB is extremely cerebral. The model is largely concerned with state-able beliefs and makes less room for non-verbal information.

Hine, Marks, and colleagues (2007) recently challenge the effectiveness of the TPB in predicting pro-environmental behaviours; they reckon TPB focuses exclusively on cognitive determinants of decision making and behaviour. In a similar way, Kollmuss and Agyeman (2002) think TPB's underlying assumption that people act rationally is a limitation of the theory. In addition, according to a study about pro-environmental purchasing behaviour done with 1093 participants, the path between intention and actual purchase (behaviour) in their structural equation model was found to be weak (Mostafa, 2007). Given that Ajzen (1991, p.181) presumes that "Intentions are assumed to capture the motivational factors that influence a behavior; they are indications of how hard people are willing to try….", TPB may not be a very effective model in predicting pro-environmental behaviour. While there is a link between stated intentions and actual behaviours, it is often weak.

Kollmuss and Agyeman (2002) think that pro-environmental behaviour is so complex that it cannot be explained through one single framework or all encompassing model. Monroe (2003) suggests that a simple pro-environmental behaviour may consist of a few hidden actions. She used bike commuting as an example. Bike commuting may include finding the safest route, bringing spare clothes and spotting a place for clothes changing plus other possible considerations an individual has to make before he or she perform the behaviour (cycling). Each component could be a potential reward as well as a barrier. Therefore, pro-environmental behaviours consist of both pro-environmental intentions and practical reasons. In the study of commuting choice, Collins and Chambers (2005) found that there is an interaction between situational (practical reasons) and psychological (pro-environmental intention) factors when predicting pro-environmental behaviours.

Some neurologists believe that many processes in the brain occur automatically and without the involvement of our consciousness. In such way, our mind is prevented from being overloaded by simple routine tasks. But when it comes to decisions, individuals tend to assume they are made by their conscious mind. Challenging such folk concept, Soon, Brass, Heinze and Haynes (2008) have unravelled how the brain actually unconsciously prepares our decisions. In their study, participants were asked to make their decision to press a button with their left or right hand. They were free to

make this decision whenever they wanted, but had to remember at which time they felt they had made up their mind. By monitoring the micro patterns of activity in the frontopolar cortex which is part of the presupplementary motor area of the brain with fMRI, they attempted to find out what happens in the brain in the period just before the person felt the decision was made. After analysing the micro patterns, they discovered that they are able to predict the decision. More importantly, they discovered that there were significant time differences between the moment the brain signal was recorded and the moment the participants reported their decisions were made. In the most extreme case, the brain activity recorded was 7 seconds ahead of reported time. The result implies that decisions are unconsciously prepared before individuals are aware of that occuring.

Affect Heuristic

Regarding the low prediction of pro-environmental behaviours with existing models, Hine et al. (2007) suggest that factors other than cognitive determinants have to be considered. Based upon Zajonc's (1980) Affective Primacy Hypothesis and the findings of Finucane, Alhakami, Slovic, and Johnson (2000), Hine et al. (2007) conducted a study on wood burning heater users. Significant results in the prediction of policy support plus behavioural switching resulted when the factor of affect is included in the model (Hine et al., 2007).

It was not very common to study pro-environmental behaviours as products of decisions making processes (Kollmuss, & Agyeman, 2002). Hine et al. (2007) attempted to portray pro-environmental behaviours as products of pro-environmental decisions. They measured the affect level of the residents of Armidale, Australia towards wood fire heaters in order to predict their decision in support of the new policies that control wood fire heaters (Hine et al., 2007). Besides Hine et al. (2007), Wilson and Dowlatabadi (2007) also, suggest that it is important for researchers to understand how individuals make their decisions before they design their intervention model in their energy consumption study.

For centuries, how decisions were made was regarded as a rational cognitive process, mainly by philosophers (Sayeg, Anthony, & Perrewe´, 2004). However, nothing had been done to find out the

potential contribution of emotions even when it was believed that the less involvement of emotion, the better the decision to be made would be (Descartes, 1994). Nevertheless, publications of researches that were intended to find out the possible weight of emotions in the procedure of human decision making were rare despite common sense suggesting emotions are among the factors in human decision making (Pérez Nieto, Fernández-Abascal & Miguel-Tobal, 2009).

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Affective Primacy Hypothesis

Robert Zajonc (1980) was among the first to challenge the traditional models which proclaim that affect is post-cognitive, in which the overall affective judgements can only be generated after the objects are cognized and evaluated. He argues that affective reactions towards an object or a situation often surface even when there is no given information of such object or situation for accomplishing a cognitive or thought process. Based on his observation to the formation of social perceptions, he argues that instance judgement to a stranger is natural and unavoidable. He further applied this observation to the formation of impressions other than social perceptions by introducing the example of people's response to a house that people do not just see a house but a handsome or an ugly house. One remarkable aspect of first impressions (affective reactions) of persons or objects is their immediacy. We know within a fraction of a second whether we like the person or not when we meet a stranger. Such reactions are instantaneous and automatic. Judgements are often accompanied by affective reactions that cannot always be voluntarily controlled. We might be able to control our expression of an emotion but are not able to control whether we want to experience an emotion or not. It is difficult for us to escape the reaction that the person impressed us as being pleasant or unpleasant. Since affective judgments are inescapable, they cannot be focused as easily as cognitive processes. For such a reason, affect may play a more important role in decision making than we are willing to admit. He suggests that a decision could be made without any prior cognitive process as he believes that an animal's first level of response to the environment is affective. The initial decision is a simple rule of adaptation which is to either initiate approach or avoid behaviour. Zajonc (1980) believes that affect is among the first links that eventually differentiated animals from plants in the evolution of complex adaptive functions.

In fact, Zajonc (1980) believes that affective reactions are the dominant reactions of lower organisms to stimuli. Even for higher organisms, affective reactions are still, most of the time, their first reactions to stimuli. Higher organisms (for example, people) are able to like something or be afraid of it before they know precisely what it is and perhaps even without knowing what it is. He argues that even higher organisms rely on such simple reactions in order to handle their daily tasks. He used a hypothetical example of a rabbit avoiding a snake attack to demonstrate how affective reactions function better than a complex cognitive processing system and the major reason is that affective reactions are potentially fast. He also argues that cognitive processing often consumes more energy than affective reactions. Since it is such a well functioning system, Zajonc (1980) believes that the affective system operates most of the time independently of the cognitive system. However, the two systems are not totally independent; at any point of a cognitive process, feelings (affective reaction) may be aroused. Meanwhile, there may be new feelings (affective reactions) after some cognitive activities have been executed. In his original words "In nearly all cases, however, feeling is not free of thought, nor is thought free of feelings." (Zajonc, 1980, p.154).

Feelings are always there even when we are not aware of it. Such affective reactions are difficult to verbalize, yet people and other higher organisms are able to communicate their affect through nonverbal channels efficiently (postures and gestures). Zajonc (1980) argues that people often select the information they collected for justifying their decisions after they were made.

Another suggestion by Zajonc (1980) is that people are not easily moved to reverse their initial affective impression of a person or of an object. This makes affective judgement almost irrevocable. People are always ready to admit the fact that they have done their cognitive analyzing wrongly but they know that they will never be wrong about what they like or dislike (affect trumps reasoning). Such stubbornness in initial decisions is the reason Zajonc (1980) believes cognition-based prediction models may be prone to error. This may be a plausible reason TPB is not highly effective in explaining pro-environmental behaviour. While the TPB has room for affect in it, the role is indirect and after the person has reasoned about their attitudes and beliefs.

Somatic-Marker Hypothesis

Damasio (1994) who was inspired by his findings from the Iowa gambling task (Bechara, Damasio, Damasio, & Anderson, 1994) proposed the idea of the somatic-marker hypothesis. Damasio and colleagues tested his hypothesis with patients who suffered from brain damage in the orbitofrontal cortices. Patients who suffer damage in orbitofrontal cortices are not able to experience emotions. Participants who are healthy were able to choose cards advantageously before they realized which strategy was best while the patients were not able to choose cards advantageously even after they have figured out the optimal strategy. By measuring the skin conductance level of participants, Bechara et al. (1994) discovered that participants without brain injury started experiencing negative emotions when choosing the wrong cards after the first ten rounds. They were able to choose the correct cards after fifty rounds. However, it was only after around eighty rounds when participants were able to explain the pattern they observed. The most important result of their study is that patients suffering from orbitofrontal injuries (who do not experience any emotions) are not able to make correct decision even after they have spotted and were able to explain the pattern they have observed. Without emotions, those participants were not able to act or decide according to the knowledge they have learned. Such finding supports Damasio's argument is that without emotions, humans are not able to make appropriate decisions. Another way to describe it is that feelings could be an integral component of rational decision making (Zimmerman, 1996).

One of the key ingredients in Damasio's (1994) idea is the belief that the mind is embodied in the body. Not just the brain itself but the interconnections with other organs as well. It can be described as a complex circuitry connecting the brain and the entire body. Neurons are connected to the terminals all over the body of an organism. They control one's instincts. Damasio uses the example of the instinct to eat which is the consequential action of such instinctual regulation of maintaining the blood sugar level inside an animal's body to illustrate the mechanism. Such a regulation system is a survival mechanism. In Damasio's (1994) words "saving your body"(Damasio 1994 p.116). The body initiated the signal. The signals are being processed by the regulation system and finally actions being taken by the body. It is a "pre-organised mechanism" that keeps an organism alive. The mechanism is also able to deal with the environment, which means an organism is able to take corresponding actions that perception of bodily states allows an organism to classify an experience as "good" of "bad" based on what effect it causes in the body. Any circumstances that lead to positive feelings to the body would be regarded as good; while anything that causes harm to the body would be felt as bad. The advantage of such a biological regulation system is that it is highly physical which allows simple organisms to learn the skills of survival rapidly. In simple words, the brain is, most of the time, an instinct regulation mechanism.

With an increase in brain capacity, higher level organisms equipped with such instinctual systems are capable of extending the circumstances in which these mechanisms operate, so they extend beyond situations directly relevant to survival. Damasio (1994) suggests that even complex social behaviour of people, traces back all the way to instinct regulation. Damasio's (1994) idea coincides with Zajonc's (1980) suggestion that affective reaction is the first stage of reaction to a stimuli of an organism mentioned above, which is purely physical. Somatic markers help animals to choose the best option, highlighting those options which are best and worst relative to the body. The best option, naturally, would be that which most likely leads to survival and pleasure where long term gratifications are less likely to be included (Zimmerman, 1996).

Affect Heuristic Model

Based on the work of Zajonc (1980) and Damasio (1994), Finucane and colleagues (2000) introduced the notion of an affect heuristic, in order to give a more equal footing to the influence caused by affect with the cognitive weighing of risks on decision making. They attempt to construct a model in which images of objects or settings are tagged as positive or negative and are stored in human memory as an "affective pool". During the process of decision making, 'records' from the affective pool are retrieved. In simple words, when a decision is being made, the brain will first retrieve the record of the corresponding topic and simply assesses the affective pool for the object or setting. This is a mental short-cut and Finucane et al. (2000) label it as affect heuristic judgement. Their model describes decision making as a process governed by two entirely different systems. The first system is a quick process, which involves little conscious input and is automatic (affective) which they call an experiential system; while the second system employs a series of conscious evaluations of risks and benefits (cognitive) which they call it an analytic system. Naturally, the experiential system is a quick and low effort system and is reckoned to be the default system in decision making (Hine et al., 2007). Such a system requires very little or no conscious input from the decision maker and is automatic.

Since both analytic and experiential systems are valid in a person's mind, Finucane et al. (2000) conduct a two part study in order to ascertain if the affect heuristic is involved in decision making processes. In the first part of the study, participants were given a series of topics in which level of risks

and benefits are directly proportional to each other. That means the level of risks is positively correlated to the corresponding level of benefits. One of the items used in the study was roller blading which is an activity that brings entertainment (benefit) but with the chance of injury (risk). The rationale for Finucane et al. (2000) to introduce the notion of risk and benefit is that the two perceived factors are quantitatively mirroring each other on the opposite sides of the balance even though sometimes they are qualitatively different. In the roller blade case, entertainment is very different from potential injury qualitatively but the participants were expected to be able to compare them quantitatively. Under normal circumstances, level of risk and level of benefit of those events are positively correlated with each other. If people are judging the situation with the analytic system, they will presumably be rating the risk and benefit at similar levels.

The participants were assigned into two groups where one group has to rate the risks and benefits level of each item within a limited time. The other group were required to perform the same task without time limit. The risk and benefit perceptions of the group given limited time were found to be significantly negatively correlated. That supports their hypothesis that the experiential system is the quicker process in decision making. In the second part of the study, four different kinds of information designed to manipulate affect were provided to the participants. Information was given which increased or decreased the perceived benefit or perceived risk. Their results support the theory. Risk and benefit are apparently derived by reference to an overall affective evaluation of the stimulus item.

From Finucane et al.'s (2000) finding, it is known that risks and benefits are assessed not only from rationale cognitive analysis but also include embodied affective tags as well. They are physical feelings similar to pain or joy which people can feel when they are using them to make decisions. In order to find out how affect works in the decision mechanism, Hine et al. (2007) went beyond Finucane et al.'s (2000) finding by measuring the level of affect directly. They measure the affect by first asking people to give three thoughts about wood fire heating which indicate the affective response (associations) towards wood fire heating. Hine et al. (2007) built a predicting model that uses the affect and risk and benefit of a wood fire to predict the level of policy support. The result supports their hypothesis that the affective associations would moderate the relationship between risk perceptions and policy support.

Finucane et al.'s (2000) study on affective pool has one important implication which was seldom mentioned – affect should not be bounded by the verbalised concept of risk and benefit. In Zajonc's (1980) original framework, affect is beyond the boundary of semantic knowledge. He suggests that affect could be transformed into visceral or muscular symbols instead of direct verbal referents. It is for such a reason, Zajonc (1980) believes that it is important to remember that sometimes, the verbal or other cognitive representations that accompany the corresponding affective experience are often imprecise and ambiguous. Therefore, the level of risk measured in Finucane et al.'s (2000) study is almost certainly not the actual risk level in the mind of the participants. Such a risk level is only the imprecise representation of a participant's feeling towards the given topic. In other words, affect is the actual judgement of an animal to a stimulus while the verbal descriptions are the distorted signals. That is what exactly affect is - a simple representation of the summary of preference, perceived risk, analysed risk, perceived benefit and calculated benefit etc. (Finucane et al., 2000; Finucane et al., 2003). The unknown mechanism was being described as a dance of affect and reason (Finucane et al., 2003).

Despite the work of Zajonc (1980), Damasio (1994) and Finucane et al. (2000), there are very few studies including affect in decision making, though the number of studies has quickly increased since the early 2000's (see Pérez Nieto, Fernández-Abascal & Miguel-Tobal, 2009). Since the perceptions of benefits and risks are the inaccurate representation of the original affect we experienced, it would be necessary to investigate the method to measure affect directly in order to develop a more accurate prediction model of affect heuristic. However, there is not a solid definition for affect in a heuristic model. Even Finucane et al. (2003) admit that affect does not have a precise definition among researchers in the field of emotion. While Zajonc's (1980) original framework excludes a lot of complex emotions; there seems to be many confounding and affect related variables that are difficult to include in a model. The affect heuristic is promising, but poses some real research barriers.

Embodiment

We still have to wait for some breakthroughs in technology that allows us to investigate the mechanism of how thoughts and feelings generate the affect tag together as proposed in the affect heuristic. However, the researchers above have a common suggestion that such affect tags are

embodied. Indeed, Zajonc (1980) proposes the possibility that locus coeruleus is a network in the central nerve system and is capable of processing affect independently. Damasio's (1994) somatic marker hypothesis suggests that emotions, including complex feelings, are processed by our nervous system which has evolved from the simple body regulating systems centred on the limbic system and its peripherals.

Since affects (or feelings) are embodied, it is worth considering how affect states could be measured directly from bodily conditions. According to Mauss and Robinson's (2009) review on emotion measurement, there are over ten variables that reflect participants' affect state. The physiological reactions caused by emotions involve the autonomic nervous system (ANS), which comprises sympathetic and parasympathetic branches, and these are generally associated with activation and relaxation. There are already many activities of various organs that have to be measured in order to analyse the affect states (Mauss & Robinson, 2009). This includes skin conductance level (SCL), heart rate (HR), blood pressure (BP), total peripheral resistance (TPR), and heart rate variability (HRV), etc. Another common variable – the amplitude of the eye blink can be measured with an electromyogram (EMG). Brain activities at any specific region can be measured by functional magnetic resonance imaging (fMRI). All these measurements have to be performed in a controlled environment which limits the degree of freedom in methodology.

Besides the complicated procedures for measuring physiological responses, Mauss and Robinson (2009) have pointed out an important aspect that the type of emotions cannot be identified merely by the measurements of physiological reactions. Some emotions cannot be readily identified by the physiological reactions they induced; Apter (1992) showed that both anxiety and excitement are able to trigger the same bodily reactions. Self-report is often the most direct and simple way to describe the valence of an emotion (Mauss & Robinson, 2009). Yet, self-report may not always be accurate for reasons like the denial of emotions (Fiedler, 1998). External observation of facial and other physiological expressions may compensate the shortcoming (Mauss & Robinson, 2009) but the accuracy is challenged by Barrett (2011) who notes division among researchers concerning the relative influences of universal and cultural factors in the production of assume emotional facial expressions.

Since transient affect state is difficult to measure accurately with current technology, investigating the phenotypic personality trait could be an alternative method to find out how the body contributes to decision making.

Testosterone is regarded as the major factor of male aggressive behaviour (Apicella, Dreber, Campbell, Gray, Hoffman, & Little, 2008). Moreover, there were researches showing that testosterone contributes to risk taking behaviour of both sexes (Stanton, Liening, & Schultheiss, 2011).

Precisely, there are two types of testosterone which were found significant in predicting risk taking behaviours; they are the prenatal testosterone and the circulating testosterone (Stenstrom et al., 2011). It is not known which type of testosterone contributes more; biologists have long debated the contributions of organization effect (prenatal testosterone) and activation effect (circulating testosterone during puberty) to the development of organisms but with no solid answer (Diamond, 2009). Neave, Laing, Fink, and Manning (2003) found no evidence to support prenatal testosterone level may predict circulating testosterone level. Both types of testosterone remain independent factors in predicting risk taking behaviours.

It is, however, difficult to measure circulating testosterone. One way is to measure it from the saliva samples collected from participants (Apicella et al., 2008). There is another factor that has to be well controlled when collecting samples of saliva which is the time of collection. Circulating testosterone level varies according to the environment; it was found that people generally have higher level of circulating testosterone in the morning (Coates & Herbert, 2008). Even postures were found to be able to elevate circulating testosterone level (Carney, Cuddy, & Yap, 2010). No research has been done about the right time that circulating testosterone level should be measured before the task. While for prenatal testosterone, instead of measuring it directly, a proxy makes the measurement simple.

The postnatal 2D : 4D ratio (the ratio between the length of the second finger and the fourth ring finger) correlates negatively with high levels of foetal testosterone (in relation to foetal oestradiol levels) in the earlier measured amniotic fluid (Manning, J. T., Scutt, D., Wilson, J., & Lewis-Jones, D. I., 1998), via the action of the Homeobox genes, which control the development of both the urinogenital

system including and fingers (Kondo, Zakany, Innis, & Duboule, 1997). Accordingly, the ratio serves as a retrospective marker of the level of circulating testosterone in utero, along with the individual's sensitivity to testosterone (Breedlove, 2010). Therefore, 2D:4D ratio is a proxy of the level of prenatal testosterone exposure.

As mentioned above, no evidence was found to support that prenatal testosterone level predicts circulating testosterone level. How prenatal testosterone influences the human body condition years later is not known yet. Nevertheless, numerous studies show that 2D:4D ratio correlates with risk taking behaviours (Coates, Gurnell, & Rustichini, 2009; Fink, Neave, Laughton, & Manning, 2006; Stenstrom, Saad, Nepomuceno, & Mendenhall, 2011). In the study of Stenstrom et al. (2011), the 2D:4D ratio of the male participants was found negatively correlates with their risk taking scores across all five domains of the domain-specific risk-attitude scale. The five domains of risks are financial risk, health/safety risk, ethical, social and recreational risk respectively (Weber, Blais & Betz, 2002). There were debates among researchers about the coherence across the domains of risks (Hanoch, Johnson & Wilke, 2006; Schonberg, Fox, & Poldrack, 2011). Bungee jumpers may manifest conservative decision making approaches in financial risk tasks (Hanoch et al., 2006). Schonberg et al. (2011) also point out that existing models, which have mostly been designed for predicting economic risky decision making, have limited success in naturalistic risk taking behaviour since 'cold' cognitive constructs still fail to capture fully what are largely emotional decisions. On the other hand, 2D:4D ratio correlates with various risk decisions and behaviours in a few studies. In Coates, Gurnell and Rustichini's (2009) study of the performance of traders in the stock market, 2D:4D ratio was found to be a significant predictor of performance (profit) which is the opposite of one of the hypotheses that a risky decision will lead to great lost. In another study, 2D:4D ratio was found to correlate negatively with participants' scores in sensation seeking (Fink, Neave, Laughton & Manning, 2006). In a study of Balloon Analogue Risk Task, participants with low 2D:4D ratio and exposed to a low social power condition were found to use riskier approaches (Ronay & Von Hippel, 2010).

From the studies above, 2D:4D ratio is apparently a better predictor involvement in risky behaviours than traditional cognitive constructs. Yet, there is no explanatory model that describes the mechanism of prenatal testosterone level influencing a person's behaviour years later. Coates, Gurnell and Rustichini (2009) suspect that early testosterone level may of sensitize a person's body and brain in a

way that lead to the later effects. However, no longitudinal study about the influence of 2D:4D ratio in human development process appears to have been published.

Only a few studies look at the 2D:4D ratio in younger participants. One study has compared the faces of a group of young male with ages aged 4 to 11 years (Meindl, Windhager, Wallner, & Schaefer, 2012). Participants' faces were analysed according to their shapes and features. It was found that the masculinity of the face is negatively correlated to the corresponding 2D:4D ratio. The important implication of this study is that the association between 2D:4D ratio and facial robustness can be observed before puberty. Meindl et al. (2012) hypothesize that children who experienced higher prenatal testosterone may behave more competitively, which may fortell different life-history strategies. In a similar study, Burriss, Little and Nelson (2007) suggest that certain aspects of masculine facial development may possibly be associated with differing perceptions of the self by others. Those aspects are predictable before adolescence (Nute, Orth, Moss, & Orth, 2000). Furthermore, such differing perceptions of the self could be an important factor in a person's development in terms of intra-sexual competition and mate acquisition (Burriss, Little, & Nelson, 2007). Therefore, such self perception could possibly be governed by factors that are established prenatally.

From an evolutionary perspective, their masculine faces give those young males greater chances to be identified as masculine and risk-taking persons at the early stage of their life. In a study of adult female perception of adult male faces, it was found that females rated the faces of males with lower 2D:4D ratio to be more dominant and masculine. In another face perception study, masculine faces of males were being identified as aggressive especially by male viewers (Macapagal, Rupp, & Heiman, 2011). Being endorsed by the surrounding people as dominant and masculine, their behaviour might be shaped in certain ways. Unfortunately without longitudinal studies, the exact contribution of 2D:4D ratio to the development of young children's personality traits remains unknown.

Two 2D:4D ratio researches were done by asking participants to recall their childhood behaviour. In the study by Burton, Henninger, Hafetz and Cofer (2009), it was revealed that 2D:4D does not just correlate with current level of aggression, but the gender-typical childhood play throughout the development of females. Four questions were asked to evaluate the gender-typical childhood play. One of those questions was the frequency of engagement in rough-and-tumble play (rough-housing)

which we may regard as the primary level extreme sports. Another question was the amount of injuries (stitches was explicitly mentioned) the participants had during those childhood play episodes. Females with low 2D:4D ratio were found to have engaged in rough play significantly more often than females with high 2D:4D ratio during their childhood. There were no significant differences within the male group yet their average rough play engagement is found to be higher than females. If we apply the definition of risk taking (sensation seeking) by Zuckerman (1979), it is not difficult to see that those participants were displaying strong urges to experience risk taking games even though they do get hurt physically sometimes. Such an urge could be seen as an embodied affect tag caused by exposure to high level of prenatal testosterone.

The second study involved a group of participants with congenital adrenal hyperplasia (CAH) and a group of unaffected participants (Hines, Brook, & Conway, 2004). CAH is a genetic disorder causing the overproduction of adrenal androgen including prenatal testosterone and was the cause of low 2D:4D (Brown, Hines, Fane, & Breedlove, 2002). The recalled childhood gender role behaviour was assessed with the Pre-School Activities Inventory (Golombok & Rust, 1993). PSAI was developed to assess participants' interests in sex-typical childhood toys and activities with 24 items (e.g. enjoying rough-and-tumble play, playing with vehicles, weapons, dolls, or jewellery). Female participants with CAH were found to recall more male-typical childhood play behaviour (Hines et al., 2004). Among males, no significant difference was found between CAH males and control males; yet, the average scores of both male groups are not lower than the average score of the CAH female group.

Both studies above provide no explanation why prenatal testosterone level correlates with young female's male-typical behaviour. The two studies, however, both show that such behavioural patterns have an early onset which to some extent, reflect the organizational effect of prenatal testosterone. With the relative high scores for male groups, we can only suppose the possibility of a ceiling effect.

From the results of the above two studies, it is suggested that females with high exposure to prenatal testosterone tend to engage more in male-typical behaviours. Other studies of male-typical childhood play suggest that behaviour could be regulated by deferential socialization (Granié, 2010). In Granié's (2010) study on preschoolers in France, it was found that female's injury-risk behaviours declines with increasing age. With the indirect measures filled out by the preschoolers' parents, Granié (2010)

argues that children's behaviour conform to masculine and feminine stereotypes as their ages increase. Masculine stereotype conformity turns out to be a better predictor of risky behaviours than biological sex. Being recognized as masculine, i.e. being viewed by their parents as strongly adopting behaviours and personality traits that society attributes to the male sex, predicts risky behaviours in preschoolers, whatever a child's sex is. So, risk taking is actually, or at least partially, the behaviour pattern being in accordance with the social stereotype one identifies with.

Earlier, Granié (2009) had already conducted a study of adolescent pedestrians. The results showed that risky behaviours among pedestrians can be predicted by masculine sex-stereotype conformity, which leads to a weaker internalization of traffic rules. Females tend more than males to internalize rules related to risky pedestrian behaviours. Granié (2011) then conducted another study on the gender stereotypes associated with driving among adolescents (age 10 to 16). It was found that male drivers are viewed as better drivers (compared with females) but at the same time they are viewed as careless and offending. There is also a general increase with age in the negative image of female drivers. In another traffic related research study, this time completed on the campus of the University of Liverpool, males were observed more often than females to cross busy roads when it is risky to do so (Pawlowski, Atwal, & Dunbar, 2008). Males were also found more likely to initiate a crossing in high risk conditions.

From the above research, it is not difficult to find a consistent message – risk taking behaviours in transportation is regarded as masculine by society. For those who are masculine and at the same time want to be identified as masculine, we predict greater engagement in risky behaviours on the road. The 2D:4D ratio may be an embodied marker of socialized masculinity. In addition, in a study involving young males in the age range 10 to 17 years, it was found that the participants with lower 2D:4D ratio, perform significantly better than those with higher 2D:4D ratio in short distance (50 metres or less) running (Manning & Hill, 2009). In another study, Manning, Morris and Caswell (2007) found that 2D:4D ratio predicts the performance of endurance running; indicating that prenatal testosterone could be a significant determinant of aerobic metabolism. Also a study of both secondary and tertiary students found that those students with lower 2D:4D ratio achieve significantly higher grades in physical education (Hönekopp, Manning, & Müller, 2006). They also have significantly higher exercise frequency (Hönekopp et al., 2006). Another study involving rowers also shows that 2D:4D indicates

cardiovascular efficiency as well as physical power among male rowers (Longman, Stock, & Wells, 2011).

The 2D:4D ratio may also be a marker for increased physicality. Perhaps, decision making for physical risky activities, is related to embodied traits. More radically, the decision itself, may be partially embodied (as in partially determined by physical traits).

The Present Study

Road cycling is a very dangerous activity. The U.S. customer product safety commission (2000) once published a report revealing that among the group of adults, age ranging from 35 to 54 years, there were over 60,000 cycling related injuries that require emergency treatment in the year 1998. It was the highest number of sports injuries in that year. If people are aware of the risk level of cycling, there has to be a very high benefit level to persuade people to make the rational decision to participate in cycling. The high number of cycling related injuries in relation to the number of cyclists suggests the general population should have a general concept of the danger of cycling.

Besides being dangerous, cycling is also a physically demanding activity. According to a study done in Australia, males who commute on their bicycles are significantly less likely to suffer from obesity than males who commute in their cars (Wen & Rissel, 2008). LaChausse (2006) regard cycling as an endurance sport that requires regular training.

In the current study, the decision to commute by bicycle or use some other form of transport was investigated using the framework provided by Hine et al.'s (2007) wood fire study. Additionally since Schwerdtfeger, Heims, and Heer's (2010) study of male driving behaviour found the 2D:4D ratio to be correlated negatively with traffic violations, suggesting that prenatal testosterone may be determinant of males risky driving behaviour, 2D:4D ratio was also measured. We, therefore, combined elements of the Theory of Planned Behaviour (attitudes regarding the belief in the benefits of cycling), the Affect

Heuristic (affective responses toward cycling), and the embodiment perspective (2D:4D) to predict both policy support for cycling and the actual choice to commute by bicycle.

The first hypothesis of this study is that in the absence of considerations of physical risk and following the Theory of Planned Behaviour, it is predicted that expressed levels of environmental concern will be positively correlated with the support level for policies that encourage bicycle commuting.

The second hypothesis is that perception of cycling risk will be greater for those with more negative affect towards cycling. In addition, the perception of cycling risk will be greater among females, and for those with higher 2D:4D ratios (indicating less exposure to testosterone during foetal development).

The third hypothesis is that the relationship between 2D:4D ratio and the perception of cycling risk will be stronger for females than for males. Because males are more likely to be encouraged culturally to engage in physical risky behaviours, the relationship for 2D:4D and risk perception is likely to be attenuated in men due to ceiling effects in physical risk taking. For females this will not be the case.

The fourth hypothesis is that commuting by bike will be more prevalent among those with stronger expressed environmental concern, lower 2D:4D ratios and greater perceived risk of cycling.

Method

Participants

Eighty-one female and 66 male participants were recruited by the experimenter around the campus of the University of Canterbury with using convenience sampling. Chocolate bars were given as incentive for their contribution to this study.

The sample consisted predominantly students or staff of the University of Canterbury. The mean age is 21.3 years (S.D. = 5.35 yrs) ranging from 16 to 46 years.

Materials and Measurements

Materials used in this study include the questionnaire specially designed for this study, Perspex finger measuring tube, permanent marker, calliper, standard map of Christchurch city, information sheet and the participants' consent form.

Questionnaire

A questionnaire inspired by the wood fire heating done in Armidale (Hine et al., 2007) was designed for this study. The current study included scales and item that assessed participants' affective associations with road cycling, perceived environmental benefits of cycling, perceived risks of road cycling, and the level of support for policies that promote road cycling. Participants' age and sex was also obtained. Participants' current bicycle commuting practice was also measured as a dichotomous variable.

Additional questions probed general cycling habits. In order to test the first hypothesis, an environmental concern scale is included in the questionnaire as the predictor variable.

The Environmental Beliefs Scale developed by Collins and Chambers (2005) was adopted and slightly modified for this study in order to measure the environmental concern of participants, targeting their views towards their daily commuting. In order to help the participants to focus on cycling as an option of commuting, the scale was modified to suit the purpose (Cronbach Alpha = 0.751). It consists of 14 items reflecting the level (1 to 5 scale) of various environmental beliefs. The grand total of the scores will be used as the predictor variable of the first hypothesis.

Participants' level of support for pro-cycling policies (response variable) were assessed by the level of financial support they think is appropriate to promote cycling. Such level of financial support is measured by three main items which are, their willingness to invest in pro-cycling policies, the proportion of spending on pro-cycling policies among other daily council expenditures they would recommend, and the amount of money to be given to each cyclist as an incentive that they think is appropriate in order to reduce car usage. The first question of policy support was about the how much they will support the levy of $200 for each resident in Christchurch in a five-point Likert-type format (1 = Strongly oppose, 5 = Strongly support). Participants were told that such levy is mainly for improving road cycling facilities in Christchurch.The second question of policy support was about how much they think the council should spend on pro-cycling policies. In a hypothetical scenario that $100,000 is to be granted for improvement of Christchurch city which participants have to recommend how the above funding should be distributed among five hypothetical projects. Finally, the third question was about incentive. By asking the participants to choose the amount of which they think are appropriate, among five options ranging from zero to $750, as monetary incentive to encourage cycling.

The individual risk perceptions (response variable of the 2nd hypothesis and predictor variable of 4th hypothesis) were measured by asking them to rate how risky it is to cycle on the road (1 = not risky at all, 5 = very risky).

Participants' affective associations with cycling on the road (predictor variable for 2nd, 3rd and 4th hypothesis) were assessed using the approach developed by Peters and Slovic (1996). With a simple highlighted cue phrase "riding a bicycle on the road within 10 seconds", participants were required to list the first three thoughts or images that came to mind and to write them on the questionnaire. The reason participants were asked to finish this task within 10 seconds is to simulate the experiment condition of Finucane et al. (2000) that participants were asked to make their judgement within limited time. A set of 3 five-point Likert-type format scales ranging from 1 (very negative) to 5 (very positive) was used to rate the thoughts. The three affective response scores will be averaged to form a composite index of affect valence by the researcher.

The complete questionnaire can be found in Appendix A.

Finger measuring tube

The precision of measurement of fingers is an important factor of this study. Inspired by a recent finger length study done by Nicholls, Orr, Yates, and Loftus (2008), transparent Perspex tubes were used to measure the fingers' length of the participants. Such method was adopted because it is a highly effective and easy-to-use method was developed to measure finger length up to the nearest 0.1 millimetre. Each tube is 17 centimetre long with a diameter of 3.5 centimetre. (See Figure 1.)

Figure 1 Illustration of the measuring tubes slipped over the fingers of the left hand.

Map of Christchurch

The accurate (relatively) distance between home and workplace is measured by measuring travelling distance between the circled locations (+/- 200 meters) of home and workplace on the standard city map of Christchurch.

Procedure

Participants were encouraged to elicit three visual images about cycling on the road and were then asked to rate each image they gave on five-point scale with labelled endpoints. In order to reduce the chance of participants giving their images and the corresponding ratings from a non-associative manner, they were reminded to get the imaging part and the rating part done within ten seconds each. They were then left to finish the remaining of the questionnaire.

Each participant's second (index) and forth (ring) fingers' lengths of both hands were marked with black permanent marker on their corresponding Perspex tubes. The marked fingers' lengths were measured with a standard calliper with an accuracy +/- 0.05mm at a much later stage. Such measurement was inspired by the study done by Nicholls et al. (2008) which was designed to provide a quick and easy-to-use means of measuring finger length. Instead of using transparent tubes with mm scale printed on it, the lengths of fingers were marked on the tubes with a permanent marker which was measured with a calliper. This modification of the measurement method enabled the measurement to be made quickly in the field with less chance of error. Each participant's 2D:4D ratio (predictor variable for 2nd, 3rd and 4th hypothesis) was calculated by dividing his/her second finger length by the fourth finger length.

Finally, the participants were asked to circle roughly the location of their home as well as their normal work place on a given map of Christchurch city.

Results

Policy Support

In order to test the first hypothesis, a multiple regression was performed. The total of all environment concern scale questions was entered into the regression together with other predictor variables which include the average of the 3 ratings of the affective associations, sex of individual participants (female coded as 1 and male coded as 2) and the 2D:4D ratio. The response variable is the standard score of the 3 policy support questions. Environmental concern is found to be the only significant predictor variable (B=0.403, p<0.01). Details of the regression result is shown in table 1. The results show that participants who have high environmental concern scores (pro-cycling commuting attitudes) also have higher self-reported pro-bike commuting policy support. Therefore, the first hypothesis is supported. Such a finding is consistent with the Theory of Planned Behaviour. Participants who score high on environmental concern and pro-bicycle riding attitudes (e.g. see cycling as beneficial) choose to support policies which lead to a more environmental protected community (Armitage & Conner M. 2001). However, the answer given in regards to policy support requires no actual obligations (the participant is not actually risking anything, except hypothetical money).

Table 1 Summary of multiple regression analysis: affect, environmental concern, sex and 2D:4D ratio as predictors of bicycle promoting policies.

Predictors	AdjR^2	B	Std.Error
Model	.153**		
Affect		-.086	.059
Environmental Concern		.403**	.103
Sex		-.006	.117
2D:4D Ratio		-.045	.675

** p<.01

Risk Perception

In order to test hypothesis 2 and 3, a two-step hierarchical regression was performed. Affect, Environmental concern, Sex and 2D:4D ratio were entered as predictor variables into the first step of the regression while Risk perception was input as the response variable. In order to test hypothesis 3, both variables (Sex and 2D:4D ratio) were centred at zero and multiplied together to compute the interaction. The interaction was then entered into the second step of the regression as the predictor variable. The result is shown in table 2 and figure 2. Affect, Sex (Female coded as 1 and Male coded as 2) and 2D:4D ratio were found to be significant predictors. The mean risk perception among female group (M=3.65, SD=0.854) was higher than in the male group (M=3.26, SD=0.933), $t(145)=2.663$, $p<0.01$. The interaction between sex and 2D:4D was also significant. Correlation between cycling risk perception and 2D:4D ratio were tested for both Female and Male group. Among females, the correlation was not found to be significant ($r=0.071$, n.s.). Among males, the correlation was found to be significant ($r=-0.271$, $p<0.05$ 2-tailed).

Table 2 Summary of two-step hierarchical regression analysis: affect, environmental concern, sex, 2D:4D ratio and their interaction(sex & 2D:4D) as predictors of road cycling risk perception.

Step	Variables	B	R^2Change
1	Affect	-.258**	.123**
1	Environmental Concern	.080	
1	Sex	2.352*	
1	2D:4D Ratio	.292*	
2	Sex X 2D:4D Ratio	-2.33*	.025*

*p<.05, **p<.01

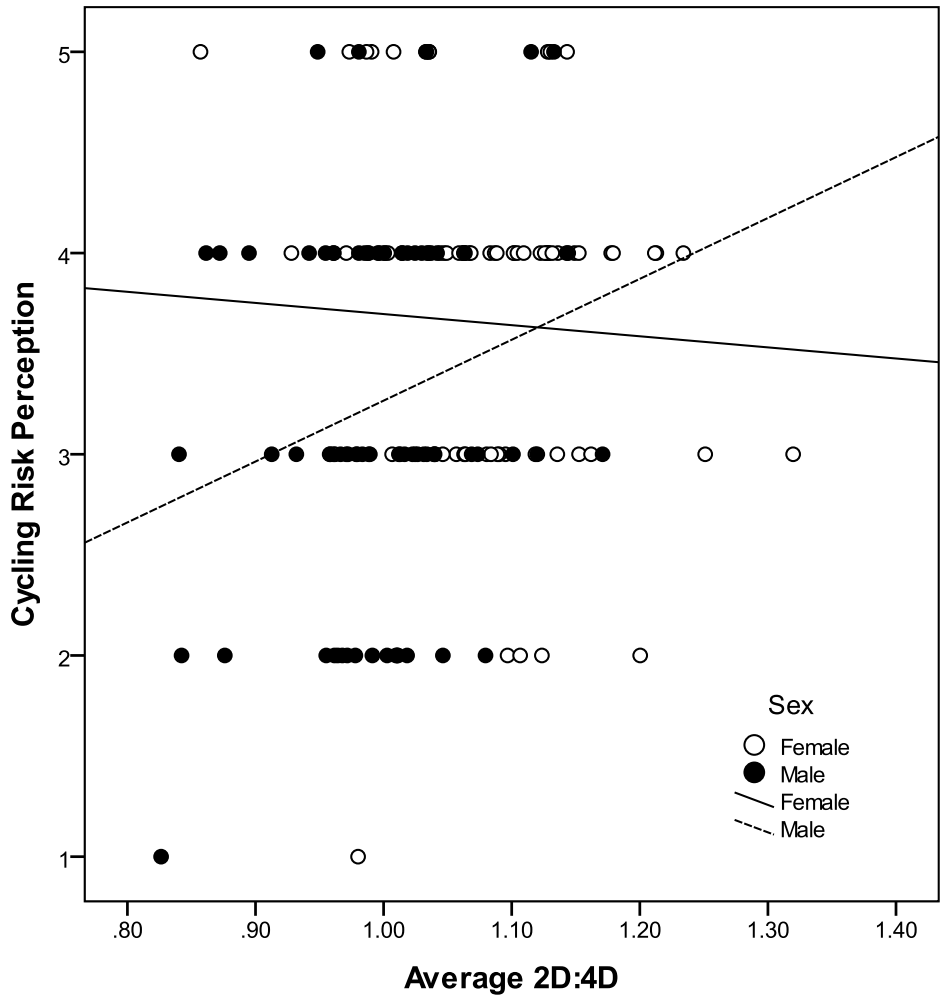

Figure 2 Scatterplot showing the moderation of the Main effects of Risk perception and 2D:4D ratio by sex.

Actual bicycle commuting behaviour

In order to test hypothesis, a logistic regression was conducted with affect, Environmental concern, Sex, 2D:4D ratio and Risk perception were entered into the model as the predictor variables. The actual bicycle commuting habit was coded as 0 (no) and 1 (yes) before being entered into the regression model. The result is shown in table 3 and figure 3.

Table 3 Summary of logistic regression analysis: affect, environmental concern, sex, 2D:4D and risk perception as predictors of bicycle commuting behaviour.

Predictors	R^2	B	SE	Wald	Exp(B)
Model	.169**				
Affect		-.264	.235	1.266	.768
Environmental Concern		.902	.415	4.731*	2.465
Sex		-.368	.436	.710	.692
2D:4D Ratio		-5.469	2.707	4.082*	.004
Risk Perception		-.496	.223	4.938*	.609

*p<.05, **p<.01

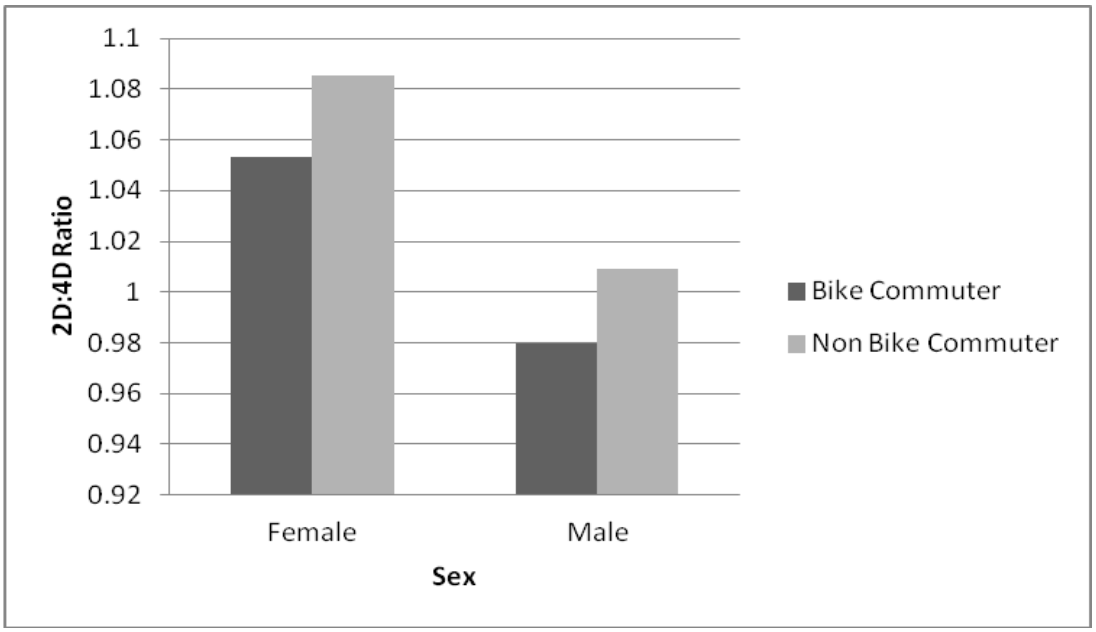

Figure 3 Interaction between Sex and 2D:4D ratio in the prediction of actual bicycle commuting behaviour.

Other findings

The mean commuting distance among female group (M=7.21, SD=6.90) and male group (M=6.535, SD=6.47), t(139)=0.602, n.s. However, the mean commuting distance among non-cyclists (M=7.713, SD=7.453) was longer than that of cyclists (M=5.314, SD=4.55), t(135)=2.367, p<0.05.

Discussion

Policy Support

The results show that participants who have high environmental concern scores (pro-cycling commuting attitudes) also have higher self-reported pro-bike commuting policy support. Such a finding is consistent with the Theory of Planned Behaviour. Participants who score high on environmental concern and pro-bicycle riding attitudes (e.g. see cycling as beneficial) choose to support policies which lead to a more environmental protected community (Armitage & Conner M. 2001). However, the answer given in regards to policy support requires no actual obligations (the participant is not actually risking anything, except hypothetical money).

Risk Perception

Cycling risk perception, which is significantly predicted by affect, sex and 2D:4D ratio and supports hypothesis 2. In the second step of the regression, a significant interaction was also found when the variable sex X 2D:4D ratio was added to the model.

Since there was a ceiling effect in young boys' childhood gender role behaviour in a previous study (Hines et al., 2004), an interaction between sex and 2D:4D ratio is expected in a specific way. The risk perception of the male group was expected to be stable (low variance) and with a low correlation with 2D:4D ratio. For the female group, an inverse correlation between risk perception and 2D:4D ratio was expected. The results, however, support a different interpretation. Female participants' risk perception levels seem not to be affected by their corresponding 2D:4D ratios, while for male participants, their risk perceptions correlate negatively with their 2D:4D ratios (see figure 2 in the result section). Perhaps, females are encouraged culturally to not perform physical risky behaviours and this suppresses the relationship between 2D:4D and risk perception amongst females. Whereas for males there is no cultural suppression of physical risk taking behaviour. Instead of a result due to a ceiling effect in risk taking amongst males, it may be instead due to a floor effect in the female group. This partially supports the hypothesis, but the mechanism is different than anticipated.

The possible explanation of such a difference could be caused by the possible differences in the formation of risk perception of the two sexes. Gustafson (1998) suggest in a review that risk perception could be socially and culturally constructed. In that case, the upbringing of a person may determine his/her risk perception to a specific item. In that case, we may take a closer look at Granié's (2010) study.

Granié's (2010) study of preschoolers shows that among children of age 3 to 6, reported injuries decreases according to their age for both boys and girls while the injuries of boys remain higher than girls across their ages. The same study also found that the frequency of injury-risk behaviours is predicted by the conformity to male stereotype (masculinity scores) which is decreasing among preschool females and is increasing among preschool males.

With no objection to the fact that Androgens contribute to the early injury-risk behaviours, Granié (2010) used the idea of Maccoby (1988) that sex-based segregation does not only stop girls from practicing masculine behaviours with boys; it also prevent girls from displaying masculine behaviours in front of their own group to explain her findings. In a similar way, boys are strongly discouraged from engaging in activities that go against the stereotype (Maccoby, 1988).

The above findings explain the results of the current study that there is an interaction between sex and 2D:4D ratio in the prediction of risk perception. It is the organization effect that high level of prenatal testosterone simply leads the young children, especially males to participate more in injury-risk activities. Through the participation of those activities, the children develop the skills which help to reduce the chances and consequences of getting injured.

Besides developing the skills to avoid getting injured, frequent participation in risky activities may actually alter one's risk perception. As risk perception is subjective and experiential (Deery, 1999) and involvement in a certain risky behaviour may not always lead to negative consequences, such as injury or penalty, that may increase the sense of competence (Horvath & Zuckerman,1992). In that case, risk

perception may be a consequence, not a cause of behaviour (Machin, & Sankey, 2008). Such an proposal is in line with Apter's (1992) idea about "protective frame". Apter (1992) describes protective frame as a flexible self-constructed buffer zone (sometimes by one's skills) that allows a person to get close to the danger situation but confident enough he/she will not enter the trauma zone which is the potential negative consequence. Because of that, Ulleberg and Rundmo (2003) even challenged whether there is a causal relationship between risk perception and behaviour.

Another important theory that Granié's (2010) mentioned in her study was from the study of Hillier and Morrongiello (1998) about the risk appraisals of young children. It must not be forgotten that risk perception could be multi-dimensional.

According to Morrongiello's (1998) finding, young boys and girls view risk in different ways. The risk rating by girls is better predicted by the vulnerability ("will I get hurt") while the risk rating by boys is better predicted by the severity ("how hurt will I get"). Yet there are no significant differences between young boys and girls in rating the severity, vulnerability and overall risk assessment (Morrongiello, 1998). In a similar study, it was found that young boys attributed more injuries to bad luck, rated risk of injury as lower, and expressed more of an optimism bias than young girls (Morrongiello and Rennie, 1998). Besides the difference in young boys and girls' appraisals to risk, Morrongiello and Dawber (1999) also discovered that parents generally have different standards for boys and girls. They found that parents prefer to remind their daughters about caution and safety while encouraging their sons to be risk taking.

From Granié's (2010) suggestion that children's behaviour conform to masculine and feminine stereotypes as their ages increase it is possible to surmise that adults' preference towards certain behaviour are driven by the conformity to the gender they identify with.

Road cycling is practically a dangerous activity but there is no evidence showing that it has been categorised as a male or a female activity. Bicycle manufacturers generally produce both male and female versions of products. According to historical account, there were bicycles designed for women back in the 1890's (Bathurst, 2011). Women were not discouraged from travelling on their bicycles

even back in the nineteenth century (Willard, 1895). Unlike the rough childhood play measured in the previous studies (Burton et al., 2009 ; Hines et al., 2009) , there is no specific gender stereotypical issue for road cycling for females. Therefore, both males and females have similar chances to experience road cycling. With their experiences, males and females are both able to judge whether road cycling is the option they want to choose based on their experience rather than the approval of the society.

However, there is a possibility that the risk perception of females of road cycling is influenced by social perception more than that of males. According to Granié's (2010) finding, females reduce their masculinity scores and engage less in injury-risk activities as a result of the rejection of the stereotypical behaviours of the opposite sex. That may not be the result of the social stereotype towards female cyclists but the social stereotype towards female are in general more vulnerable. A study shows that even children rate girls as having a greater risk of injury than boys, although young boys routinely experience more injuries than young girls (Morrongiello et al., 2000). Therefore, females are not being discouraged to commute by bicycles but still carry the belief that they are more likely to get hurt.

That may indicate the limitation of our current understanding of risk perception and decision making. There may be a gap between the risk perception and risk taking behaviour among individuals which we have never become aware of. Perhaps most of the risk studies show that females are more risk averse than males in both their perception and behaviour (e.g., Byrnes, Miller, & Schafer, 1999; Eckel & Grossman, 2002). There is one activity which is an exception and that is sun tanning (Sjöberg, Holm, Ullén, & Brandberg, 2004). Sun tanning is found to be more common among females despite the fact that females are more aware of the risk (Sjöberg et al., 2004). Sjöberg et al. (2004) regard that as the result of unrealistic optimism.

In this study, there is not enough evidence to show which group is manifesting unrealistic optimism. But if we take a close look at the results, we might get some insights. The correlation between risk perception and 2D:4D ratio among female participants is insignificant ($r = 0.07$). For male participants, the lower the 2D:4D ratio, the lower the risk they perceived.

Female participants' risk perception is significantly higher than that of the male participants ($p < 0.01$). Also, the S.D. of female group's risk perception is 0.854, lower than 0.933 of the male group. As mentioned, the risk of road cycling is high, even when it is in terms of getting severe injuries. Yet, there is a correlation between the risk perception and the 2D:4D ratio among the male participants. It is possible that it is caused by the specific attitude of male towards risk taking. Hawkes (1991) introduced her show-off hypothesis which proposes that human male may gain respect from both sexes by engaging in risky hunting tactics despite the fact that hunting often is not the most efficient way to obtain food. Besides mate attraction which is a long term reward, human males with skills and courage at hunting or warfare sometimes may be granted sexual favours from females for their courageous acts and often their acts impress other males that he is a good person to have as a friend and hunting partner. With the support of other males, the chances of survival and the inclusive fitness of those males will increase. If we apply that to our bike commuting study here, it is possible males who commute by bike are displaying their fitness quality to both males and females.

There are not many research studies that explore the mentalities of road cyclists. One of the studies done by LaChausse (2006) reveal that male cyclists were more likely to endorse competition than female cyclists while females were more likely to endorse affiliation and self- esteem as reasons for cycling. For bike commuters, there should be no obvious competitor but there is a possibility that male bike commuters see other road users (mainly drivers) as competitors. Studies of drivers' behaviours show that the presence of passengers will increase the chances of a crash for young male drivers (Jackson and Gray, 1976; Doherty, Andrey, & MacGregor, 1998; Preusser, Ferguson, & Williams, 1998). Wilson and Daly (1985) regard this as the 'young male syndrome', suggesting that males have to gain a higher status to enable them to compete against older males of higher social rank and greater resources. Even the competitive manner of male cyclists may only happen during their adolescence, it may give them enough chances of exposure to risky cycling experience. Peterson, Gillies, Cook, Schick, & Little (1994) suggest that repeatedly experiencing near injury or minor injuries may lead to a child becoming desensitized to the possibility of severe injury outcomes. For children with low 2D:4D ratio, Meindl et al. (2012) hypothesize that they may experience different life-history strategies which shape their risk perceptions' formation towards various daily activities.

Actual Commuting Behaviour

The logistic regression of the actual cycling behaviour of the participants has shown that environmental concern, risk perception and 2D:4D ratio are the significant predictors of actual cycling behaviour.

Among the predictors, 2D:4D ratio is the strongest one. Affect was in the prediction model but found to be insignificant. That is not in line with the findings of Finucane et al. (2000). However, if we revisit the idea of Zajonc (1980), Finucane et al.'s (2000) study could have forgotten the role of embodied feeling. As mentioned above, there have been numerous studies examining in the correlation between 2D:4D ratio or testosterone and risk taking behaviours. However, no research examining the correlation between 2D:4D ratio and risk perception could be found. In the current study, 2D:4D ratio was found to be a significant predictor of risk perception. Revisiting the study by Finucane et al. (2000), affect guides perceptions of risk (Slovic & Peters, 2006). Such a concept was based on the idea of Zajonc (1980) which states that feeling is embodied. His idea is a direct foreshadowing of his later work on embodied emotion, and also his investigation on the vascular theory of emotion efference (Winkielman, 2010).

Zajonc's understanding about empathy is that people know one another through their emotional reactions and the process of knowing is the use of the motor system to encode and represent information (Niedenthal, Augustinova & Rychlowska, 2010). Challenging the mainstream ideas that cognitive representations are either in the form of either propositions or images, Zajonc and Markus (1984) think it can be in the form of motor processes. As they suggest that humans are capable of representing the emotional state of the others by facial mimicry (motor behaviour), emotions can be originated and operate noncognitively and unconsciously (Winkielman, 2010).

If emotions can sometimes be unconscious, then human affective states will not be fully verbalised. However, from the implication of Finucane et al.'s (2000) finding, such embodied visceral states may alter human's risk perception markedly. The finding of this study that 2D:4D ratio being a significant

predictor of risk perception may support Zajonc and Markus's (1984) idea of such embodied and unconscious affect, although there are other explanations as well.

Houwer and Hermans (2010) raised the daring question if feelings have a mind of their own after reviewing most of the subsequent research occurring after Zajonc's (1980) publication. They suggest that in order to manage most of its daily tasks, it would be an effective option for an organism to develop an automatic affective processing system. Such a process is automatic and can be independent from higher cognitive processes thus making the entire process give us an impression that feelings operate like an intelligent being (Houwer and Hermans, 2010).

One aspect of Zajonc's (1980) idea worth deeper research is the embodiment of affective processing. As Zajonc (1980) suggests that in most cases, affects are encoded into visceral or muscular symbols rather than being transformed into semantic contents. Before complex brains were evolved, early organisms were already placed into circumstances where they had to make decisions on how to act when facing environmental challenges. In that case, we should ask the question if the body has a mind of its own. That means we should investigate if the body is capable of managing some of its daily tasks automatically without waiting for the brain to process the signals. Apparently, such a proposed mind is not the traditional Cartesian view of the mind; yet, in line with Damasio's (1994) argument that the mind cannot be separated from the body, the role of the body has to be re-considered.

It may not be an acceptable way to describe the body functioning as if it has a mind of its own. However, if we look at the body as a system with a well organised work procedure for handling many of the daily tasks without alarming the brain, it is not difficult to classify such a system as something having a pseudo-mind. Recently, some biologists even argue that intelligence has to be redefined so that there will be a category as plant intelligence. Plant neurobiologist Anthony Trewavas (2005) argues from a biological perspective that intelligence should not be limited to organisms with conscious minds. He emphasises the fact that plants are capable of adapting according to their corresponding environmental challenges because of their phenotypic plasticity. Such phenotypic plasticity of plants is regarded to be equivalent to movement of animals (Trewavas, 2005). With such plasticity, a plant is then capable to adapt wisely in order to maximise its survival chance and forage for food and resources. This kind of adaptation process is similar to how a highly intelligent animal solve

its survival challenges as it includes sensory perception, information processing, learning, memory and choice (Trewavas, 2005). He further argues that plants should be regarded as prototypical intelligent organisms which initiated a serious debate, other biologists argue that plants have no neurons and therefore, it is not logical even to start considering the possibility of plant intelligence (Alpi et al., 2007). Such controversial idea has given old 'Root-brain' idea a chance to resurface (Calvo Garzo´n, P. & Keijzer, F., 2011). They argue that plants are able to make correct decisions even without a nervous system. Through a well developed but simple sensing system, plants are able to grow accordingly (not randomly) in order to survive. Carnivore plants are even able to 'hunt' without a brain (Krol E. et al., 2012). In simple words, plants are able to take the correct actions rather than telling the outside world the correct answers and plants have been playing this survival game successfully.

Zajonc (1980) changed the paradigm that decision has to be made thought rational information processing. Following the logic of the biologists above, I argue that our body has the ability to by-pass the conscious mind and make the correct decision (take the correct actions) under certain circumstances. From the results of the current study, there seems to be a possibility that the participants' bodies were making their decisions to take corresponding actions rather than through cognitive functions. Their bodies were taking action according to the information they could collect while their minds were giving social-cognitive answers to the researcher.

Such capability may not fulfil all the definitions of intelligence, but may certainly be able to influence the decision making of an organism. The influence I use here is not bounded to some facts that have to be considered during the cognitive process. The influence here means the body may send out strong signals to the entire system instructing itself how to act. Such an automatic system is effective yet flexible. The body is able act on its own and at the same time consult the higher-brain areas (or mind) or at least let the brain learns what it has done.

In the regression model, the 2D:4D ratio may be considered an indirect measurement of the somatic response to the formation of risk perception of road cycling. Such a compromised method was adopted because the technology of measuring all related somatic responses towards a certain stimulus is yet to be developed. Moreover, the interpretation of physiological reactions to emotions is under development. Both excitement and anxiety are very different experiences; yet they lead to identical physiological reactions (Apter, 1992). In the current study, the 2D:4D ratio – the proxy of prenatal

testosterone was allocated to the regression model to test the individual differences of participants' somatic tolerance to risk. We may presume that the 2D:4D ratio is a marker of the baseline of how the human body perceives and judges how risky a situation is, even before the brain has actually attained any knowledge about the situation. As Zajonc (1980) suggests 'Preferences Need No Inferences', an organism is able to make judgement to a certain situation even without any corresponding information. He suspects that the locus coeruleus – a network in the central nervous system is able to process affect independently. If so, then besides the somatic marker proposed by Damasio (1994), there could well be a rapid somatic response system to support human in handling some of their daily tasks.

By comparing individuals' 2D:4D ratio, we are able to know how the differences in their bodies reaction or judgement to a situation. From the previous studies mentioned in the introduction section, it is known that 2D:4D ratio is negatively correlated to various types of risk taking behaviours. While we are very far from understanding why 2D:4D would impact bike commuting decision making, the relationship is intriguing. Whether 2D:4D is a somatic marker of risk tolerance or an indicator of physical ability (as some studies do find a correlation between 2D:4D ratio and physical ability), it may influence the decision to commute by bike. At the very least, psychologists should not forget people have bodies, that they vary in shape and form, and that this makes a difference in decision making, especially those decisions involving physical risk. This suggests theories of decision making, for example the Theory of Planned Behaviour and the Affect Heuristic, could be augmented in some cases with direct somatic information.

Limitation

This study is about commuting. There are many practical reasons that a person has to consider before making the decision. It is not possible to compare the weight of those reasons as individuals have different preferences. For some people, carrying more than 5 kg may already deter them from bicycle commuting.

Future Development

2D:4D ratio is a proxy of the body and in the current study, it was used to represent the expected affective responses. It is suggested that affective responses be measured directly. Instead of asking

participants to rate the affective associations, let the participants imagine the situation and report the valence. The feeling can be measured by electronic equipment and various physiological metrics.

Participants in this study live in different sections of the city. If possible, temporary accommodation could be provided in order to find out how people act differently under the same environment. Or, recruit participants from the same neighbourhood.

Conclusion

This is the possibly the first study that attempted to combine the somatic response, affect, risk perception and perceived reward in one model to predict risk taking behaviour. Traditionally, psychologist attempted to compare all the factors in a linear scale –balancing between feelings and cost and benefits. Maybe it is time we should start searching for the means to measure the non-verbal feelings which we believe to be playing a significant role in human judgements and decision making.

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Appendix A : Questionnaire

Bicycle riding and use questionnaire

1. List **3** thoughts/images that come to your mind about **riding a bicycle on the road within 10 seconds.**

   a._____

   b._____

   c._____

   Rate the above thoughts/images on a scale **from 1 to 5 within 10 seconds** accordingly.

   a. 1 2 3 4 5

   Very negative *Neutral* *Very positive*

   b. 1 2 3 4 5

   Very Negative *Neutral* *Very Positive*

   c. 1 2 3 4 5

   Very Negative *Neutral* *Very Positive*

2. Imagine you live **close enough** to your workplace/university and are **fit enough** to ride a bicycle, will you use a bicycle for commuting when the weather is fine? Please make your decision **within 20 seconds**.

   1 2 3 4 5

   Very unlikely *Very likely*

3. The average cycling distance of commuters in Christchurch is around **5km**. What is the greatest distance you think you are capable of cycling regularly to university/work?

1	2	3	4	5
Much less than 5 km		*Exactly 5 km*		*Much more than 5 km*

4. If the government were to charge each person **$200** per year for maintaining a safe and extensive bike path system, how would you respond to this?

1	2	3	4	5
Strongly oppose				*Strongly support*

5. If the Christchurch City Council had received a $100,000 grant from the government for improving Christchurch, how would you like to see the money distributed to six potential projects (please do not exceed $100,000):

1.	Attracting new business	$ _____
2.	Increasing tourism	$ _____
3.	Reducing wood smoke pollution	$ _____
4.	Improving cycle ways	$ _____
5.	Improving other community services	$ _____

6. If monetary incentives could improve the relative use of cycles versus cars, how much do you think the government should give to those who reduce car usage and use bicycles instead as a credit? (Please circle the answer you think is most appropriate).

1.	$0
2.	$100
3.	$250
4.	$500
5.	$750

7. How risky do you think it is to cycle on the road?

1	2	3	4	5
Not Risky at all				*Very Risky*

8. Using a scale from **1** (*strongly disagree*) to **5** (*strongly agree*) please indicate the extent to which you agree with the following statements. Place a number in the space provided to the left of each statement.

_____a. Through my individual actions I can make a difference to the environment.

_____b. My individual actions have an impact on the environment when I choose which mode of transport to use to get to university/work.

_____c. The effect of air pollution from cars on public health is minimal.

_____d. It is necessary to conserve fossil fuels (such as petrol and natural gas) for future generations.

_____e. Using a bicycle can reduce greenhouse gas emissions that affect people all over the world due to global warming.

_____f. Using a bicycle does not create as much noise as a car.

_____g. The noise created by cars negatively affects me.

_____h. This city would be a more pleasant place for me to live if there were fewer cars on the road.

_____i. Bicycle riding has a positive effect on my health.

_____j. Today's car use will have a negative effect on me and my family in the future.

_____k. The contribution to reducing pollution by using a bicycle is negligible compared to that due to industry.

_____l. The positive effects of bicycles on the ecosystem have been exaggerated.

_____m. Drilling for liquid oil poses a threat to the environment.

_____n. Over the whole earth, pollution from cars has a minimal impact on plant and animal life.

9. Do you currently use a bicycle to commute from home to university/work ? Y/N

10. How far do you live from the university/workplace? Approximately _____ km

11. How many hours **each week** do you spend cycling ? Approximately _____ hours.

Please circle the purpose(s) (You may circle more than one item or none.).

a. Commuting

b. Leisure/Sport

c. Others

12. For your answer to Q.11 , please estimate the percentage for each.

a. Commuting _____ %

b. Leisure /Sport _____ %

c. Others _____ %

13. What percentage of commuting trips do you travel by (please fill in the relative percentage; the total should be 100%).

1. car _____%

2. city bus _____%

3.	walking	_____%
4.	cycling	_____%
5.	other modes of transport	_____%

14. Do you intend to use a bicycle for commuting more often in the future?

1	2	3	4	5
Very Unlikely				*Very Likely*

15. Are the following conditions significant in your decision in Q.14 above?

a. Too far	Y/N
b. Carry too many things	Y/N
c. Have to go somewhere far away before/after work/uni?	Y/N
d. Cannot (not skilful enough) to ride a bike	Y/N
e. Don't have a bicycle/helmet (or bike is broken)	Y/N
f. Physical constraints	Y/N
g. Prefer using buses	Y/N
h. Someone offers me a lift	Y/N
i. Giving someone a lift	Y/N
j. Helmet ruins the hairstyle	Y/N
k. Never bother to consider cycling	Y/N
l. Others (please specify)_____	

16. *AISS* – Intensity subscale

Using a scale from **1** (*strongly disagree*) to **5** (*strongly agree*) please indicate the extent to which you agree with the following statements. Place a number in the space provided to the left of each statement.

_____ a. When the water is very cold, I prefer not to swim even if it is a hot day.

_____ b. When I listen to music, I like it to be loud.

_____ c. I stay away from movies that are said to be frightening or highly suspenseful.

_____ d. If I were to go to an amusement park, I would prefer to ride the rollercoaster or other fast rides.

_____ e. I would never gamble with money, even if I could afford it.

_____ f. I like a movie where there are a lot of explosions and car chases.

_____ g. In general, I work better when I'm under pressure.

_____ h. It would be interesting to see a car accident happen.

Your Age : _____

Your Gender : Female / Male

Left hand

Length of 2nd finger : _____ Length of 4th finger : _____

Right hand

Length of 2nd finger : _____ Length of 4th finger : _____

For Experimenter only

Initial Cycling distance _____ km Uphill? Y/N

Follow up questions (5 weeks later)

FQ1. Cycling (commuting)? Y/N FQ2. How many days a week? _____

FQ3. Address changed? Y/N FQ4.Further/Closer

FQ5. Other reasons

FQ6. Do you intend to use a bicycle for commuting more often in the future?

1	2	3	4	5
Very Unlikely				*Very Likely*

Remarks :

Appendix B : Human ethics approval

Ref: HEC 2009/LR/92

16 October 2009

Tak Woo

Department of Psychology

UNIVERSITY OF CANTERBURY

Dear Tak

Thank you for forwarding to the Human Ethics Committee a copy of the low risk application you have recently made for your research proposal "Cycling to work: a rational choice or an affect heuristic decision?".

I am pleased to advise that this application has been reviewed and I confirm support of the Department's approval for this project.

With best wishes for your project.

Yours sincerely

Dr Michael Grimshaw

Chair, Human Ethics Committee

Appendix C : Information Sheet

Information Sheet

You are invited to participate as a subject in the research project. The aim of this project is to investigate the correlations between people's affect, risk perception, and decision making.

Throughout the project, you will remain anonymous. You will be required to fill in a questionnaire with some personal information, which are the lengths of your fingers, the distance between your home and your work place, and your contact details. All records of your contact details will be securely destroyed in about 5 weeks after a few follow up questions are answered. The entire procedure should take approximately 20 minutes.

All information given by you and the application will not bring you any foreseeable risks. You have the right to withdraw from the study at any time, including withdrawal of any information provided before the information stored anonymously.

The result of the project may be published, but you are assured of the complete confidentiality of data gathered in this study. To ensure anonymity and confidentiality, information will be securely stored in the Psychology department at all time and non-identifying information will be coded for anonymity.

By completing the following questionnaires it will be understood that you have consented to participate in the project, and that you consent to publication of the results of the project with the understanding that anonymity will be preserved.

This project is being carried out as part of a Master Thesis by Tak (T.C.) Woo (tcw30@uclive.ac.nz) under the supervision of Doctor William (Deak) Helton (deak.helton@canterbury.ac.nz). They will be pleased to discuss any concerns you may have about participation in the project.

The project has been reviewed and **approved** by the University of Canterbury Human Ethics Committee.