

# TRAVEL BEHAVIOUR CHANGE THEORIES AND EXPERIMENTS: A REVIEW AND SYNTHESIS

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## ABSTRACT

Travel Demand Management (TDM) strategies aim at changing the behaviour of travellers in order to reduce the demand for single occupancy car travel, and to redistribute car users to public and non-motorised modes. The success or failure of TDM strategies – measured by change in vehicle kilometres travelled or modal share – depends upon a robust understanding of what causes travellers to change patterns of behaviour. Many theories have been employed across a range of disciplines to explain behaviour change. A variety of travel behaviour change experiments have been conducted over the previous decade – based either explicitly or implicitly on particular theoretical frameworks – in order to observe the effect of TDM measures and test the veracity of theories. These experiments have typically employed before-and-after survey and control-and-experiment group techniques in measuring behavioural change. This paper reviews, categorises and synthesises theories concerning behaviour change, and the behaviour change experiments that have been conducted. The paper concludes with discussion on the link between theories and experiments, and future research plans.

## 1. INTRODUCTION

Travel demand management (TDM) measures are emerging as central to strategies aimed at reducing carbon emissions, and as an alternative to road capacity increase in managing congestion. TDM measures aim at changing travel behaviours in order to reduce the demand for single occupancy car ridership, and to effect shifts towards public and non-motorised travel mode use. This has proven, in most instances, to be difficult to achieve. To formulate effective TDM strategies it is therefore important to understand the how and why aspects of travel behaviour choice, and when behavioural change occurs. The complexity of factors that directly or indirectly affect choice-making decisions make developing such an understanding difficult.

The aim of this paper is to review theories relevant to travel behaviour choice and change and their link to behavioural change experiments or interventions. The paper is divided into four sections. In the following section theories that explain how and why travellers make travel behaviour decisions, and when behavioural changes occur, are identified and described. Section 3 then reviews experiments in travel behaviour change. Section 4 concludes with a discussion on how experiments are linked, explicitly or implicitly, to different theoretical frameworks, and on future research plans.

## 2. THEORIES OF BEHAVIOUR AND BEHAVIOUR CHANGE

Several behavioural theories have been developed in attempts to explain what induces consumers to make choices, how these are made and when changes occur. Some of these theories approach behaviour as a function of internal factors prevalent to the individual, such as values, attitudes, personal norms, etc. Others approach behaviour as a product of external factors such as incentives, societal norms, institutional constraints, etc. (Jackson, 2005, Egmond and Bruel, 2007). A further theoretical perspective, as advanced by Stern (2000), argues that behaviour is a function of both internal and external factors, and that a better understanding of the complexities of human behaviour therefore needs to acknowledge the influence of both the individual and his or her environment.

This section identifies and reviews alternative behavioural and behaviour change theories that take into consideration a variety of internal and external factors. The theories described have been categorised according to the type of question they seek to answer: how are choices made when a decision-maker is confronted with a set of behavioural alternatives?; what factors affect choice-making?; when does behavioural change occur; and how do decision-makers respond to behaviour change interventions? (see table 1). The former two questions relate to explaining behaviour and choice-making more generally, and the latter two to explaining change in behaviour more specifically.

**Table 1. Categorisation of behaviour and behaviour change theories**

		Category of theory			
		How are behavioural choices made?	What factors affect choice-making?	When does behavioural change occur?	How do decision-makers respond to behaviour change interventions?
Rational choice theory (including bounded rationality and deficit model)	(Becker, 1976, Simon, 1957),	X			
Prospect theory	(Kahneman and Tversky 1979)	X			
Habit formation theory	(Gärling, Fujii and Boe 2001)	X		X	
Theory of planned behaviour (including theory of reasoned action)	(Fishbein & Ajzen 1975, Ajzen 1991)		X		
Theory of interpersonal behaviour	(Triandis 1977)	X	X		
Norm activation theory	(Schwartz 1977)		X		
Cognitive dissonance theory	(Festinger 1957)			X	
Stages of change model	(Prochaska and DiClemente 1986)			X	
Self-perception theory	(Bem 1972)				X
Goal setting theory	(Latham and Locke 1991)				X

### 2.1. Theories explaining how behavioural choices are made

#### 2.1.1 Rational choice theory

Rational choice theory (RCT) proposes that consumers seek to maximise their utility by calculating the costs and benefits of alternatives available to them (Glimcher et al., 2005, Simon, 1955, Scott, 2000). It is also referred to as utility maximization theory and has its

roots in microeconomic theory. The term 'rationality' has been used in two broad senses by authors over the years (Yang and Lester, 2008, Bateson, 2010). The first is concerned with the process through which an outcome is attained. The second – which is a narrower use of the term – is mainly concerned with the outcome and not by effort made in arriving at a decision. An outcome is considered rational if it maximises utility to the individual. RCT uses the latter definition of rationality.

In RCT, individuals are assumed to have comprehensive knowledge of the various alternatives (and their attributes) available to them and are capable of ranking them according to their utilities and dis-utilities (Simon, 1955). In order to do this ranking, the individual is also assumed to be capable of computing, storing and retrieving this knowledge whenever he or she wants to make a choice (Simon, 1955, de Palma, 1998). Based on these assumptions, the individual ranks the available alternatives based on their attributes. The alternative that offers the highest utility to the individual is then chosen. It is assumed that these processes of choice-making are always carried out whenever the individual is faced with a decision-making problem. Rational choice theories are considered to be individualistic, thus choices made by individuals are not affected by choices made by others.

The underlying assumptions of RCT have been subjected to much criticism over the years. Some of the assumptions criticised include that of comprehensive knowledge of all available alternatives, and the cognitive powers of the human brain in computing the various utilities and dis-utilities (de Palma, 1998, Simon, 1955, Jackson, 2005). Winston (1989), for instance, argued it is rarely rational (in the broader sense) to be maximally rational since it requires resources such as time, energy, etc. in collecting and processing information. Changes have therefore been made to the classical rational choice theories in efforts to address some of these limitations. In particular, Simon (1957) developed the principle of 'bounded rationality' in an attempt to address this limitation of the classical rational choice theory. He argued the human brain does not have the capacity to either formulate or solve the complex problems required for even a reasonable approximation of objective rational behaviour. An individual only behaves rationally with respect to a simplified model of the real world by making trade-offs. Instead of 'maximising', the individual seeks an alternative that is 'satisficing'. This means the collection of less information and less computation compared to classical rational choice theory.

RCT has dominated the conventional transport planning and modelling, in so far as it provides the theoretical underpinning of the modal split and trip assignment phases of the four-step demand forecasting model.

### 2.1.2 *Prospect theory*

Kahneman and Tversky (1979) criticised expected utility theories for being unhelpful when it comes to making decisions in which the outcome is uncertain (e.g. a route choice decision in the context of volatile congestion and uncertain travel time). They therefore advanced prospect theory (PT) as an alternative model for explaining how decisions are made which involve some degree of uncertainty.

They proposed that people try to avoid outcomes which they are uncertain about when making decisions. They do this by giving more weight to alternatives with greater certainty of outcome than others. Kahneman and Tversky showed that when gains and losses associated with choice alternatives are made more explicit, loss aversion is triggered, as the emotion of loss is stronger than the emotion of gain.

The theory comprises two phases – the editing and evaluation phases – in the decision-making process. In the editing phase – involving the coding, combination, segregation, cancellation, simplification, and detection of dominance stages (Experimental Economics Centre, 2006, Kahneman and Tversky, 1979) – the choice alternatives are organized and reformulated to simplify them for evaluation. In the evaluation phase the individual then evaluates the alternatives by applying decision weights and subjective values. The alternative with the highest value is chosen.

The use of PT in travel behaviour studies have concentrated more on travel and arrival times than modal choice, because of the high degree of uncertainty in the former (van Wee, 2010, Timmermans, 2010).

### 2.1.3 *Habit formation theory*

While emerging relatively recently in travel behaviour studies, the phenomenon of habitual and automatic behaviour has long been established in various fields, including biology and social psychology (McDougall, 1908). Habit has been defined as learned sequences of acts, aimed at obtaining certain goals or end states, that become automatic responses to specific situations (James, 1890, Watson, 1914). Thus, even though habit may not involve much deliberation, behaviour is still geared towards the achievement of certain goals. It is argued that the more repetitious an activity becomes, the stronger the formation of habit and the less deliberation (Dahlstrand and Biel, 1997, Garvill *et al.*, 2003, Bamberg *et al.*, 2003).

Gärling *et al* (2001) proposed the notion of script-based choice as a means to describe the process of migration from deliberation to automatic repetition of behaviour. In their conception, the individual engages in rational deliberation to locate a preference among a set of alternatives when faced with a choice decision for the first time. If a positive outcome results from the enactment of the preference-based choice, this set of steps (i.e. from deliberation, to choice, to experience of the positive outcome) becomes codified as a script which the individual can retrieve in future when confronted with the same decision-situation. Under the same conditions, the same choice is therefore repeated, forming habit.

Gärling and Axhausen (2003) argue that, if the situation remains unchanged, repeating choice after first time deliberation may be more rational or more appropriate than the maximal rationality of RCT. They argue, however, that it may not be considered rational (in the narrow sense) if the same choice is made even when the situation changes, at which time the choice may be considered as strongly habitual and cannot be changed easily by small changes in circumstances.

Habitual choice behaviour requires little or no deliberation over the various alternatives available (Gärling and Axhausen, 2003, Garvill *et al.*, 2003, Verplanken *et al.*, 1997). Inducing a deliberate choice-making process has been seen to be a step towards breaking habit (Garvill *et al.*, 2003). Measures include the provision of information about alternatives, creation of awareness, provision of incentives and disruptions in car use (Gärling and Fujii, 2006, Fujii *et al.*, 2001, Fujii and Kitamura, 2003). Dahlstrand and Beil (1997) argue that the provision of information about alternatives may not be effective in changing strong habits as compared to other measures such as disruption of traffic flow, as information on alternatives is not considered when making such choices. It is therefore imperative to know the degree of habit when formulating policies aimed at changing habitual choices.

Habit formation theories have received increasing attention in travel behaviour studies over the past decade. Some authors argue habits developed in past behaviour are a better predictor of behaviour than attitudes (Triandis, 1977, Ouellette and Wood, 1998).

## 2.2. Theories explaining what factors affect choice-making

### 2.2.1 *The theories of reasoned action and planned behaviour*

The theory of reasoned action (TRA) was developed to explain and predict volitional behaviours (Fishbein and Ajzen, 1975). TRA advances that a person's behaviour can be predicted by the strength of intention – thus intention is the immediate determinant of action (Ajzen, 1985, Fishbein and Ajzen, 1975, Ajzen, 1991). Intentions are in turn determined by attitudes toward behaviour (which are a function of behavioural beliefs) and subjective norms (a function of normative beliefs).

Ajzen (1985, 1991) argued most behaviours depend, to some degree at least, on factors such as time, money, skills and the cooperation of others (collectively representing actual behavioural control), and these factors may not always be under the control of the person. This implies that TRA cannot be used to predict these types of behaviours.

As an extension to TRA, the theory of planned behaviour (TPB) was introduced by Ajzen (1985) to predict non-volitional behaviour (i.e. the decision-maker does not have complete control of all factors determining the choice). As a third determinant of intention (in addition to attitude and subjective norm) he introduced perceived behavioural control. Perceived behavioural control refers to the perceived difficulty or ease of performing behaviour. He argued intentions in the strict sense can only predict a person's attempt to perform behaviour and not necessarily the actual performance of the behaviour. The ability of intention to predict attempted behaviour, but not actual behaviour, implies that there may be factors beyond the person's control preventing it. As a latest addition to what seems to be a continuous improvement of the TPB to predict actual behaviour, actual behavioural control has also been included in addition to perceived behavioural control (Ajzen and Fishbein, 2005).

TPB has been applied in various travel behaviour studies since its inception – ranging from public transport use (e.g. Bamberg and Schmidt, 1999) to road crossing (e.g. Evans and Norman, 1998). It has been used in explaining and measuring the influence of attitudes and beliefs on behaviour.

### 2.2.2 *Theory of interpersonal behaviour*

Like TPB, the theory of interpersonal behaviour (TIB) also defines intention as one of the influential factors of behaviour. Unlike the TPB however, Triandis (1977) also takes into consideration habit when explaining or predicting behaviour. Triandis (1977) proposed habit, intention and facilitating conditions as the three determinants of behaviour in a ranking order. Habits and intentions interact with environmental factors that either facilitate or inhibit behaviour. He argued the stronger the habit, the less the effect of intentions on behaviour, and *vice versa*.

The frequency of past behaviour is used as a determinant for habit. Intentions are determined by attitude, social factors and affection. As with Fishbein and Ajzen's TRA and TPB, attitude is preceded by belief and evaluation of outcome (representing the deliberative nature of humans), while social factors (subjective norm in TRA and TPB) is determined by norms, roles and self-concept (representing the extent to which revered individuals and society can affect behaviour). Unlike TRA and TPB, TIB considers affection

as a third determinant of intentions. This represents the extent to which the person enjoys or dislikes the behaviour.

Despite the greater predictive power of the TIB over TPB as demonstrated by Bamberg and Schmidt (2003), TIB has received relatively less attention in the travel behaviour field. Bamberg and Schmidt (2003) suggest that TIB may gain increased recognition in this field due to the insufficiencies of TPB in explaining social behaviours and an increasing recognition of habit as a major factor in travel behaviour.

### 2.2.3 *Norm activation theory*

The norm activation theory (NAT) developed by Schwartz (1977 as cited in, Bamberg and Schmidt, 2003) proposes personal norms as the determinant of pro-social behaviour. The theory was posited to explain altruistic behaviour (Darnton, 2008, Wall *et al.*, 2008). Personal norms are formed through an adaptation of societal norms (Klößner and Matthies, 2004). These personal norms are said to be activated only when the person becomes aware of the consequences of his or her behaviour and takes responsibility for them. (Wall *et al.*, 2008)

Schwartz and Howard (1981 as cited in, Klößner and Matthies, 2004) developed four-stages through which normative decisions are made: attention, motivation, evaluation and denial stages. Thus there is the need for awareness to act, which should be consistent with one's personal norms, leading to a motivation for behavioural change. This is then followed by an evaluation of the costs and benefits of enacting the various alternatives. After evaluation, the alternative with the highest utility is chosen. If no clear decision is made, the fourth stage of denial is executed, at which stage the moral component of the decision-making process is either altered or entirely removed. The process is repeated until a choice is made.

There have been mixed results in the application of NAT in travel behaviour studies. For instance, Bamberg and Schmidt (2003) found no significant relations between moral beliefs and car use, while Wall *et al* (2007) found evidence of personal norms informing car use reduction goals.

## 2.3. Theories explaining when behavioural change occurs

### 2.3.1 *Cognitive dissonance theory*

Cognitive dissonance theory (CDT) proposes that a person will try attaining consonance between two cognitions if they conflict with each other (e.g., knowledge about his or her behaviour, and the environment) (Festinger, 1957). In efforts to achieve consonance, either of the two cognitions (e.g., behavioural or environmental) would need to be changed. However because of the lack of control over one's environment most of the time, it is much easier for the person to change the behavioural cognition to reflect the environmental cognition.

In changing the behavioural cognition, the person may either change the behaviour itself or may seek to acquire more information to buttress the behaviour. For example, after becoming aware of the unsustainable nature of car use, a habitual car user may desist from using the car or may seek contrary information about its benefits to come to terms with using the car. Festinger pointed out that, even though people pursue the reduction of dissonance, it may persist because of the difficulties which may be encountered while changing either the behaviour, or the knowledge about the behaviour.

While the application of CDT in travel behaviour studies is seldom explicitly acknowledged, it could be argued that it is implicit in studies that use information as a means of changing the attitudes of decision-makers. In such cases the new information may be dissonant with the decision-maker's cognition, causing behavioural change.

### 2.3.2 *Stages of change model*

The stages of change model (SCM) – one of the constructs of a trans-theoretical model of behavioural changes developed by Prochaska and DiClemente (1986) to assess a person's prospects of changing behaviour – posits six stages through which behavioural changes occur. These are the pre-contemplation, contemplation, preparation, action, maintenance and termination stages.

At the pre-contemplation stage, decision-makers have no intention of changing behaviour as they are not aware of the problems associated with their behaviour or are in a state of denial. Through the provision of information and social pressures, decision-makers may become aware of the consequences of their behaviour (Frasier *et al.*, 2001). Decision-makers then start contemplating behavioural changes, at which stage the benefits and costs of various alternatives are considered. After the decision-makers become aware of the costs and benefits of change, they prepare for behavioural change by forming action plans. At the preparation stage, some behavioural changes may be observed (Frasier *et al.*, 2001, Darnton, 2008). The action plan for behavioural change is then carried out at the next stage where behavioural modifications can be overtly observed. The next stage – maintenance – may be considered very important in the design of behavioural interventions, especially when dealing with habitual behaviours. At this stage, the decision-maker tries to avoid a relapse to past behaviour. Maintaining the context within which the behavioural change occurred is therefore important for the new behaviour to become habitual. The new behaviour then alters personal norms and the temptation to relapse to past undesired behaviour becomes minimal.

SCM has been used in formulating behavioural interventions. Nkurunziza *et al* (2012) for instance argue that segmenting decision makers according to the different stages can aid in defining more targeted and efficient travel behaviour interventions (in this case, cycling in Dar es Salaam).

## 2.4. Theories explaining how decision-makers respond to behaviour change interventions

### 2.4.1 *Self-perception theory*

Self-perception theory (SPT) was proposed to offer an alternative explanation to the phenomena leading to Festinger's CDT (Bem, 1972, Bem, 1967). In SPT, an individual discovers or amends his or her attitudes, emotions, and other internal states by observing his or her behaviour and experience.

Contrary to CDT, and most other behavioural theories, SPT is counterintuitive as behaviour is assumed to precede attitude. In SPT, an individual's attitude towards a particular behaviour may change after enacting the behaviour in question. Jackson (2005) argues that while the assumption of behaviour preceding attitude may not always be valid, SPT can complement Festinger's CDT. Bem (1972) identifies experiments involving forced behavioural changes as examples of where SPT had greater explanatory power than CDT. In these types of experiments, participants are usually not persuaded by information (the case of CDT) or by other forms of incentives into changing behaviour, but are rather forced into doing so.

Similar to CDT, the explicit use of SPT in travel behaviour studies has been limited. However it is implicit in interventions where individuals are made to experience certain travel choices aimed at changing their attitude (e.g. the issuance of free public bus tickets [Fujii and Kitamura, 2003], or the closure of a freeway forcing drivers to use public transport [Fujii *et al.*, 2001, Fujii *et al.*, 2001, Fujii and Kitamura, 2003]).

#### 2.4.2 Goal setting theory

The goal setting theory (GST) advanced by Latham and Locke (1991, Locke *et al.*, 1981) proposes that human behaviour is motivated by conscious purpose, which is in turn regulated by the decision-maker's goals. GST focuses on the performance of behaviour – in other words, on why some people perform better than others when given the same knowledge and ability. GST states that the simplest and most direct motivational explanation for why some people perform better than others is that they have different performance goals (Latham and Locke, 1991 p. 213).

Two main factors in setting goals – content and intensity – are seen to determine the degree of performance. Content can also be divided into how specific and difficult the set goal is. People with more specific and challenging goals are seen to have higher performance towards goal attainment than those with either specific but unchallenging, vague but challenging, vague but unchallenging, or no goals (Locke *et al.*, 1981). Vaguely formed goals lead to lower performance but with higher individual satisfaction results – e.g. people with a 'do your best' goal may be satisfied with any achievement compared to people with specific goals. Also more challenging goals are seen to result in better performance than easy ones, even though they are rarely reached. They must however be set within an individual's capacity for easy acceptance of goals. Intensity determines the clarity and commitment of the person to goal attainment. Factors affecting commitment to a goal include setting achievable and appropriate goals. The more people perceive a goal as achievable and appropriate, the higher their commitment to attaining the goal. In short, for better performance in behavioural change, the goal should be specific, challenging, achievable and appropriate.

In the travel behaviour field, GST has been applied in some car use reduction studies (e.g. Loukopoulos *et al.*, 2004, Loukopoulos *et al.*, 2006), and employed extensively in several Japanese Travel Feedback Programmes based on individualised communication and hedonic feedback (see Gärling and Fujii, 2006).

### 3. TRAVEL BEHAVIOUR CHANGE EXPERIMENTS

Two broad types of TDM strategies – structural and psychological – have been formulated and executed in efforts to change travel behaviour (Steg, 2003). Structural strategies – comprising physical changes, financial-economic stimulation, and legal regulations – aim at changing the context of decision-making. Psychological strategies – involving provision of information and education – aim at increasing knowledge about transport alternatives, and awareness about the impact of decisions which may affect perceptions, beliefs, attitudes and values. A number of travel behaviour change experiments have been developed over the previous decade in which these strategies have been applied in various ways, based either explicitly or implicitly on some of the theoretical frameworks discussed in section 2. These experiments aim to change travel behaviour patterns in support of TDM strategy objectives, and typically employ before-and-after survey and control-and-experiment group techniques in measuring change.

A preliminary review and synthesis of travel behaviour change experiments and interventions follows in order to explore the link between behavioural theories and



experiments (see table 2). While not be an exhaustive review of behaviour change experiments and interventions, the dominance of TPB in explaining behaviour is evident.

**Table 2. Summary of travel behaviour change experiments**

Underlying Theory	Author/s (year)	Travel behaviour change experiment or intervention	Key results
Theory of planned behaviour	Bamberg (2006)	<p>Participants (newly relocated residents) received a one day (free) ticket to try the local bus service. They also received personalised information including a map of bus services and stops, schedules and fares.</p> <p>The free ticket and personalised information were assumed to influence participants perceived behavioural control and attitude, and thus intention to change behaviour. The selection of newly relocated households for participation indicates that HFT also informed in the experiment design, as these households had recently experienced a life cycle event in which their habits were disrupted.</p>	<ul style="list-style-type: none"> <li>An increase in public transport use from 18% to 47% was observed among newly relocated residents.</li> </ul>
	Bamberg and Schmidt (1999)	<p>Following university-wide referendum, bus fares were significantly reduced through the introduction of a semester ticket for university students. New bus routes connecting the main facilities on campus to the city centre were also introduced.</p> <p>The introduction of the semester ticket and bus routes were assumed to impact attitudes (e.g. public transport regarded as cheap and convenient), subjective norms (through public discussion and voting) and perceived behavioural control, which in turn were assumed to adjust intention to change behaviour.</p>	<ul style="list-style-type: none"> <li>A significant increase in bus use from 15% to 31% coupled with a decrease in car use from 44% to 30% was observed when semester tickets were introduced.</li> <li>No significant increase in bus use was observed after the introduction of new bus routes.</li> </ul>
	Beale and Bonsall (2007)	<p>Marketing material with information about the benefits of bus travel and the disadvantages of car travel was provided to participants in a first trial. In a second trial, one group of infrequent bus users was provided with only marketing materials about the benefits of bus travel, while a second group was provided with marketing materials and a free bus ticket.</p> <p>The intervention was targeted at correcting negative behavioural beliefs and therefore attitudes toward bus use.</p>	<ul style="list-style-type: none"> <li>48% and 48% reported bus use among the information only and information and free ticket groups respectively, as against 30% of a control group after six weeks.</li> <li>Both information only and information and free ticket groups reported 62% bus use as oppose to 47% bus use in the control group after six months.</li> </ul>
	Taniguchi and Fujii (2007)	<p>Participants were given information and free tickets to use bus services. One group of students was also encouraged to make travel plans on how to use the ticket.</p> <p>The provision of bus information and tickets enabled the adaption of perceived behavioural control, and thus intention to change behaviour. The formulation of behavioural plans by an experiment group suggests GST was implicit in the experiment.</p>	<ul style="list-style-type: none"> <li>The proportion of experiment group using the bus (38%) was more than double that of the control group (18%)</li> </ul>
	Heath and Gifford (2002)	<p>The cost of bus use was reduced by the introduction of a universal-pass to university students.</p> <p>The introduction of the universal-pass was assumed to influence attitudes and perceived behavioural control, and thus intention to change behaviour. A before questionnaire also contained questions regarding intentions to use bus services and attitude toward bus use, suggesting that GST was implicit in the experiment.</p>	<ul style="list-style-type: none"> <li>A 7% decrease in driving alone was observed while bus use increased by 11%.</li> </ul>
Norm activation theory	Hunecke <i>et al</i> (2001)	Free subway tickets were provided to participants who would otherwise use their car or motorcycle for trips to the city centre.	<ul style="list-style-type: none"> <li>61% of trips to the city centre by subway against 39% by car or motorcycle were observed amongst participants with a free ticket. 43% of trips by subway and</li> </ul>

		Through a before questionnaire, information about ecological problems and impacts was also passed on to participants, aimed at increasing awareness of consequences and personal responsibility, and adjusting personal norms.	57% by car or motorcycle was observed in a control group
	Matthies <i>et al</i> (2006)	A first group of participants were given a free ticket (valid for 14 days) and requested to commit to trying public transport. A second group were given only a free ticket (valid for 14 days). A third group were only requested to commit to trying public transport.  It was assumed that in the process of participants' committing to a behaviour change, personal norms were addressed, and that the chance of behaviour change actually occurring was increased.	<ul style="list-style-type: none"> <li>• In the first group an increase in bus use of nine percentage points was observed.</li> <li>• In the third group no increase in bus use was observed.</li> </ul>
Stages of change model	Mutrie <i>et al</i> (2002)	Participants received a targeted 'walk in to work out' pack which included information on walking and cycling routes and safety information.  These information packs were formulated based on the stages of change model. The intervention targeted people contemplating, and those preparing for, active commuting.	<ul style="list-style-type: none"> <li>• Participants in the contemplation stage walked 11.5 km per week six months after the intervention as compared to 5 km per week in the control group. Those in the preparation group added 2.3 km per week walking to that observed at baseline, compared to 0.8 km per week in control group.</li> <li>• 25% of participants at the contemplating or preparation stages were actively commuting after twelve months.</li> </ul>
	Rose and Marfurt (2007)	A ride (cycle) to work day event was promoted by issuing booklets with information on bicycle routes and facilities to participants at various workplaces.  The information booklets and events were targeted at people contemplating the use of a bicycle.	<ul style="list-style-type: none"> <li>• 80% of first time cyclist indicated the event had a positive impact on their readiness to cycle to work with 57% indicating it influenced their decision to cycle.</li> <li>• 25% of first time cyclist still cycled to work five months after event.</li> </ul>
Underlying theory not explicitly stated	Fujii (2007)	Non-driving first year university students were grouped into four groups: cost, risk, stress, and a combination of all three. They were asked to read leaflets containing cost, risk and stress information about using cars according to their group.  The provision of information on predicted personal impacts suggests that TPB (influencing attitudes) and CDT (highlighting dissonance between desirable and likely outcomes) were implicit in the experiment.	<ul style="list-style-type: none"> <li>• 53%, 39%, 30% and 47% of student respondents obtained drivers' licenses holders in the cost, risk, stress and all information groups respectively – compared to 69% in a control group after 18 months of intervention.</li> </ul>
	Fujii and Kitamura (2003)	A one-month free bus ticket was given to student car drivers along with a bus route map to facilitate public transport use.  The ordering of behaviour change before attitude change suggests that SPT was implicit in the experiment.	<ul style="list-style-type: none"> <li>• A mean frequency in bus use of 9.34 trips/month (an increase of 5.21 or 126% from baseline) was observed in the experiment group during the validity of bus ticket. This however reduced to 4.95 trips/month (an increase of 0.83 or 20% from baseline) a month after the free ticket expired.</li> </ul>
	Fujii and Taniguichi (2005)	Individualised information and advice on reducing car use was given to two groups. One of the groups was asked to make behavioural plans with respect to reducing car use.  The preparation of behavioural plans, to influence intention to reduce car use suggests that GST was implicit in the experiment.	<ul style="list-style-type: none"> <li>• A 28% reduction in total trip duration and a 12% reduction in car-use days by the planning group were observed. No significant changes in the advice group were observed.</li> </ul>
	Wen <i>et al</i> (2005)	Information containing bus schedules, fares, maps, bicycle and walking routes were provided to workers through events, poster displays and newsletters.  The provision of information on bus services and non-motorised transport alternatives as a means of influencing perceived behavioural control suggests that TPB was implicit in the experiment.	<ul style="list-style-type: none"> <li>• An increase from 37% to 45% was observed of staff reporting use of active transport as their usual commuting mode.</li> <li>• There was a 20% reduction in the proportion of staff who reported driving to work five days a week.</li> </ul>

#### 4. DISCUSSION AND CONCLUSION

The aim of this paper was to review theories relevant to travel behaviour choice and change, and to explore the link between theories and travel behaviour change experiments.

With regard to theories relevant to travel behaviour choice and change, several behavioural theories have been identified, and it has been argued that these can be categorised into four main groups on the basis of the questions they address: Firstly, theories that explain how choices are made when a decision-maker is confronted with a set of behavioural alternatives include: rational choice theory (RCT), prospect theory (PT), habit formation theory (HFT), and the theory of interpersonal behaviour (TIB). RCT and PT posit that a deliberate evaluation of alternatives occurs whenever decisions are made. In contrast, HFT posits that evaluations only occur when a decision is made for the first time, after which favourable experiences are turned into memory scripts drawn upon whenever the decision is to be made again, without going through a deliberate evaluation process. Secondly, theories that explain what factors affect choice-making include: the theory of planned behaviour (TPB), the theory of interpersonal behaviour, and norm activation theory (NAT). All these theories in second category attempt to identify the range of factors that come into play when a behavioural choice is made, but do not explicitly explain the cognitive process through which a particular behavioural alternative is chosen. These first two categories of theories may be considered as behaviour choice theories. Thirdly, theories that explain when behavioural change occurs include: habit formation theory, cognitive dissonance theory (CDT), and the stages of change model (SCM). These theories attempt to explain when a change in behaviour is likely to occur, and what causes this change. Fourthly, theories that explain how decision-makers respond to behaviour change interventions, and the strength of this response, include: self-perception theory (SPT) and goal setting theory (GST). These second two categories of theories may be considered as travel behaviour change theories.

Of these theories, RCT has dominated as the underlying framework of much travel behaviour analysis practice, while PT, HFT, TPB and GST have received growing attention in recent decades. TIB, NAT and CDT, however, remain largely unexplored in the field.

With regard to the (explicit or implicit) link between theories and travel behaviour change experiments, a preliminary review indicates the dominance of TPB as the underlying theoretical framework of many experiments – a conclusion consistent with the reviews undertaken by Ajzen (2011) and Bamberg and Schmidt (1999). Other theoretical propositions, particularly TIB, remain largely unexplored in the travel behaviour change experiment field.

An inspection of the literature on travel behaviour change experiments – from the perspective of the theoretical categorisation presented in this paper – indicates that while authors might explicitly identify one particular theory as having informed the construction of their experiment, other theoretical frameworks may also be apparent. The categorisation of theories presented in this paper demonstrates that a combination of different theories may not necessarily be contradictory, and that theories may not be mutually exclusive. A good example of this is Bamberg's (2006) experiment involving recent home movers and the provision of a free public transport ticket and personal schedule information. Within the explicit theoretical framework of TPB, the information and incentive were designed to influence participants' perceived behavioural control and attitude, and thus intention to change behaviour. The targeting of recent home movers, however, draws from HFT and in

doing so recognises that these households are most susceptible to attempting change. Further, the new information provided on public transport services may be contrary to participants' prior beliefs, causing dissonance and inducing behavioural change. Thus CDT may also overlap or complement TPB.

There appears, therefore, to be no one right or wrong theory, and considerable potential for theoretical innovation in travel behaviour experiment construction. It is suggested that it is important for formulations of TDM interventions to address the four main question categories identified in this paper: how choices are made; what factors influence choices; when change is executed; and how decision-makers respond to interventions. Context specific experimentation is also important, as a variety of external factors (e.g. quality of mode alternatives, prevailing safety and security perceptions, etc.) have an influence on outcomes, and the results of specific experiments are therefore unlikely to be replicable across all contexts. Further experimental research is planned to explore improved theoretical understanding of travel behaviour change in Cape Town, and to advance knowledge on what TDM strategies have the greatest prospects for success in the local context.

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