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Engaging in Pro-Environment Travel Behaviour Research from a Psycho-Social Perspective: A Review of Behavioural Variables and Theories

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Abstract: This paper aims to review variables and behavioural theories originating from social and environmental psychology as applied to transport research, to better understand decision-making mechanisms, information processing and modal choice. The first section provides an overview of the main psycho-social variables which explain behaviour and, notably, pro-environment behaviour. The analysis shows the relations among variables, highlighting some potential cause-effect mechanism or, at least, the influence that such variables can have on behaviour. Furthermore, the strengths and weaknesses of using psycho-social variables to predict travel behaviour are discussed. Such analysis feeds the section related to the behavioural theories. These are reviewed with a focus on potential application to transport sector, showing the would-be added value of introducing a socio-psychological approach in the current vision, focused on stochastic models based on maximisation of personal utility. To this end, attention is paid to the data collection and analysis, basic for any models and even more challenging to collect when they deal with personal characteristics of individuals. Finally, the concept of attitude and intention is discussed, opening the doors between disciplines to overcome the attitude-behaviour gap.

Keywords: travel behaviour; behavioural theories; psycho-social variables; attitudes; social simulation; data

1. Introduction

Transport is known to be the second source of greenhouse gas emissions (GHG) and the sector which relies the most heavily on petrol consumption worldwide [1]. To tackle such problems but also to provide greater accessibility to the workplace, places of leisure, shopping areas and so forth, to improve our quality of life and environmental conditions, a transport policy paradigm shift occurred nearly 25 years ago. In fact, even though social scientists and environmental psychologists began to study travel behaviour in the 70's, only since the 90's has a large amount of research been carried out to better understand modal choice from a socio-psychological point of view and to use this knowledge to try to "pull people out of their cars".

This paper aims at giving an extensive vision of the state of the art of behavioural theories originating from social and environmental psychologists and applied to transport research in order to better understand the mechanisms behind the pro-environment travel behaviour. The strengths and

weaknesses of such theories will be discussed as related to their ability in forecasting mobility habits with attention to the modal choice.

The first objective is understanding the determinants of travel behaviour, starting from the psycho-social variables that are considered key in the decision-making mechanism of individuals when choosing a transport mode. To this end, attention is paid to the variables which quantitatively explain behaviour and, notably, pro-environment behaviour (Section 2) and these are analysed in terms of their reciprocal relations and how they potentially influence the behaviour, showing the strengths and weaknesses of their use in transport sector.

The second objective, dealt with in Section 3, focuses on the individuation of the most significant behavioural theories found in the relevant literature in the last 20 years and which mainly use the variables defined in Section 2.

The third objective tackles the critical analysis of the role of variables (data), how they are analysed as well as interlinked in the models predicting the behaviour and is dealt with in Section 4.

Thanks to the outcome of the analyses presented in Sections 2–4 that shows the key issue of the gap between attitudes/intentions and behaviour, the discussion ends with some proposals to try to pave the way for the redefinition of the concept underlying the attitude-behaviour or intention-behaviour gap to better forecast travel behaviour and provides recommendations for further research.

2. Review of Main Psycho-Social Variables Related to Pro-Environment Behaviour

Naming the variables "psycho-social" stresses that the individual is socially driven and that social processes may be mediated by psychological states. Arguably, investigating the psychology of individuals to better understand their decision-making process in the modal choice appeared necessary when some researchers (e.g., [2]) drew attention to processes of bounded rationality and car dependence and the environmental psychologists integrated the psycho-social factors into transport studies to understand the determinants of pro-environment behaviour. Indeed, explaining intentions and behaviours are two different tasks that need to take into consideration a wide spectrum of subjective characteristics of individuals which explain why *people are so diverse*. These characteristics are very different in nature, come into play at various levels of consciousness and differ in degree of persistence over time. Further on, it is possible to classify the psycho-social variables that can be determinants of behaviour into eight main classes: (1) **knowledge and beliefs**, that sometimes clash with rationality; (2) **values**, seen as individual orientation (though socially embedded) about justice, goodness or ethics; (3) **worldviews (weltanschauung)**, understood as an unconscious framework within which the world is interpreted; (4) **norms**, or explicit and objective influences of others on oneself; (5) **personality traits**, which define the set of intrinsic characteristics (personality) and the set of consistent patterns (lifestyles) that will shape decision-making in accordance with a self-identification process; (6) **emotions and personal stories**, understood as anchored personal background that forges sensitive responses; (7) **attitudes and intentions**, defined as higher-level variables and strict predecessors of behaviours (behaviour-proximal variables); (8) **habits and past behaviours**. Although the last group cannot be considered a psycho-social determinant, it plays, nonetheless, an important role in understanding the issue under discussion.

Such classification is partly derived by Bonnes et al. [3] but it is mainly related to different cognitive levels. Indeed, whereas, for example, worldviews can be hardly changed during a lifetime, knowledge can be improved, emotional response can be moderated and attitudes can be changed; thus, the different cognitive levels imply different behavioural change processes. In Table 1, the eight groups of variables are shown, specifying their typologies, descriptions and scientific reference. Beside information, an in-depth analysis of strengths and weaknesses of the application of such variables in the transport sector is presented in Section 2.1, highlighting which variables can be used to improve the prediction of travel behaviour. To better understand the role of psycho-social variables in explaining behaviour as provided by the current behavioural theories, the conceptual framework synthesizing their relationships and their ability to forecast behaviour is depicted in Figure 1. Colours are used to label those variables that will be discussed later on within the context of the behavioural theories (Section 3), to better highlight diversities as well as the common elements of such theories.

Table 1. Review of main psycho-social variables explaining behaviour. Focus on pro-environment travel behaviour.

Variables	Typology/Paradigm	Description	References
Knowledge and beliefs	Declarative knowledge	It describes the system that is the organized, purposeful structure that consists of interrelated and interdependent elements continually influencing one another	
	Procedural knowledge	It allows to know how to act	
	Effectiveness knowledge	It is the knowledge of relative effectiveness of different behaviours aiming at the same outcome	
	Social knowledge	It is the representation of normative beliefs or what one believes his/her referents think about a given behaviour	
Values	Social value orientation	It represents individualism versus cooperation (e.g., prisoner's dilemma)	[5]
	General value orientation	It is appraised on a bi-dimensional scale representing four higher order values: self-transcendence versus self-enhancement and openness to change versus conservatism	[6]
Worldviews	Post-Materialism	It explains environmental concerns because people pay attention to greater general welfare in a society where basic materialistic needs are guaranteed	[7,8]
	Myth of nature	It refers to the risk perception, where people are supposed to adopt one of the four different views about the vulnerability of nature: (1) benign and resilient; (2) tolerant and moderately vulnerable; (3) ephemeral and fragile; (4) capricious and unpredictable whatever action is taken	[9,10]
	Religious orientation	It refers to the influence that religion has on people choices and behaviour, showing a potential effect on the willingness to make sacrifice	[11]
Norms	Social prescriptive norms	They reflect the beliefs of "what we should do"	[12]
	Social descriptive norms	They are based on the direct observation of "what people do", being mostly context-dependent	[12]
	Personal norms/moral	They are internalized social norms. They are activated when the subject is aware of the consequences of his/her own actions, deliberately taken	[13]
	Normative believes	They refer to the perceived behavioural expectations of the referent individuals or groups (parents, relatives, friends, etc.)	[14,15]
	Subjective norms	They are determined by the combination of normative beliefs with the person's motivation to comply with the different referents	
Personality traits	Allport's trait theory	No agreements emerge on the definition (see [16])	[17]
	16 Personality Factors		[18]
	Goldberg's Big Five personality traits		[19]
Emotions/Personal Stories	Emotional response	It expresses the affective dimension of the object (e.g., car) related to a choice (e.g., modal choice) that influences such choice	[20–22]
	Past experience	It expresses the life experiences or habits in the past (also in the early stage of life) that influence people choices	[23]
	Utilitarian response	It is used for obtaining a certain benefit, sometimes overcoming the emotional response	[3]
Attitudes and Intention	Attitudes	They generally refer to one-dimensional evaluation towards a mentally represented object, concrete or abstract	[24]
	Intention or "behavioural intention"	It is a mental state that directly precedes behaviour, a form of motivational driver that leads to the behaviour itself	[15]
	Perceived behavioural control	It refers to people's perceptions of their ability to perform a given behaviour	[15]
Habits and past behaviour	Habits	It is a recalled action-script	First used in [25,26]
	Past Behaviour	It is the previous behavioural pattern, when repeated several times	Discussion in [27]

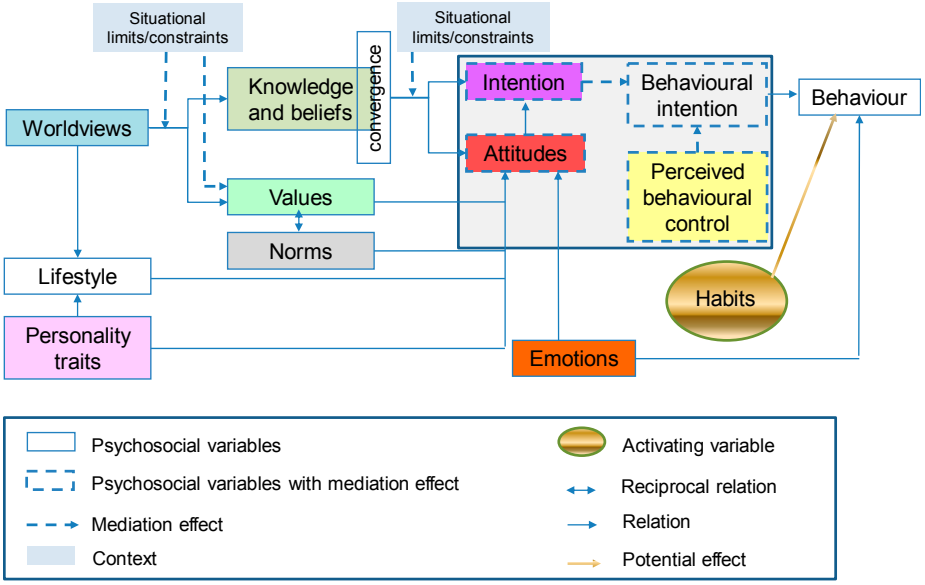


Figure 1. Role of psycho-social variables in explaining behaviour.

Although ***knowledge*** shows, empirically, a low correlation with behaviour and, notably, with sustainable behaviour [28], it does correlate with intention when situational constraints are taken into account [29] and its effect relies more probably on the synergy of its different forms (declarative, procedural, effectiveness and social, Table 1) that can enhance or inhibit each other. The convergence of all of these forms is, for some authors, a necessary—though not sufficient—condition for ecological behaviour [4] and it is mediated by attitude and intention [30] when explaining behaviour. The current taxonomies of ***value***, which are not related to specific objects or behaviours, mainly refer to unstable decision-making, largely depending on context and the salience of information when action is implemented. Values are important precursors of attitudes—and, notably, of environmental attitudes—but they can sometimes be in contradiction with the observed behaviour. The reason is that the values go beyond the context and their role in explaining behaviour is largely moderated by many other variables, such as situational limits [31] or the cultural background [32]. Similar to values, ***worldviews*** are not directly related to objects or behaviours. However, worldviews being a general mental representation of causes and effects, at a higher level of abstraction, they precede the formation of beliefs and values and their influence on decision-making is constrained by situational limits. Worldviews contribute to forming values and knowledge as well as lifestyles while they have a weaker influence on the formation of attitudes.

The ***norms*** can be social or personal (Table 1). Social norms can be acquired and internalised, becoming personal norms, through a process of self-categorisation inside the dynamics of social identity construction [13]. When a person feels part of a group, (s)he tends to act in line with the group's prescriptive norms. Other norms may remain alien to us but still have an influence on our behaviour.

Nordlund and Garvill [33] linked personal norms with personal values and found evidence that individuals showing self-transcendence and eco-centrism felt more morally forced to cooperate in a social dilemma context of modal choice. Bamberg, Hunecke and Blöbaum [34] studied the strength of socio-normative influence and argued that the more anchored the social norms are, the stronger the association between social norms, personal norms and behaviour. ***Traits*** and personal dispositions were studied long ago in psychology where they are defined as neuropsychic structures that uniquely characterize an individual and his/her ***personality***. The lack of both a common definition of personality traits [16] and common methods for measuring them creates a problem when carrying out comparative studies. However, ***personality traits*** are thought to influence travel behaviour and

activity patterns [35] through the formation of attitudes and they contribute to shaping ***lifestyles***. ***Emotions*** can be quite strong when fed by cultural and symbolic patterns [36,37] and can contribute to forming attitudes but they can also induce certain modal choices when associated to specific good or bad events when travelling.

Attitudes are a key-concept in social psychology. Despite many different definitions in psychological literature [38] often confused with other concepts in social sciences, such as opinions or values [39], attitudes are hidden psychological states of an individual about something not directly observable but partly measured through some indicators—opinions, judgements, feelings.

In the early years of social psychology, attitude was considered the direct predecessor of behaviour, although evidence showed inconsistencies in the attitude-behaviour relationship [40]; thus, behavioural intention was introduced as a mediator variable between attitude and behaviour [41]. The stronger the intention to act, the more likely the consequent behaviour is. However, in order to take into account exogenous factors hampering the implementation of a behaviour—weakening the correlation between intention and behaviour—some subjective variables related to the perceived difficulty or judgements about one's own ability to behave in a determined way may be considered [42]. Such variables can be expressed by the perceived behavioural control that is determined by the total set of accessible control beliefs [15].

Habits, even though not a psycho-social variable, can be very strong in activating a travel behaviour. From a cognitive perspective, when a behaviour becomes habitual, it is no longer seen as a deliberative choice but it is recalled through an action-script from past experience to minimise the cognitive effort and can be measured as the response-time of a given person confronted to a given situation. It has indeed been demonstrated that the more automatic the activation of a behaviour, the less people look for information to make a deliberate choice [43,44].

2.1. Strengths and Weaknesses of Application to Transport Sector of Psychosocial Variables

Only few variables among those described in the previous section and summarised in Table 1 have been used in transport sector. Figure 1 shows how most of them have some influence on behaviour but it is not much studied if they can have an effect on travel behaviour. The analysis of literature allows to hypothesise their role in travel behaviour, with a specific focus on pro-environment behaviour and modal diversion from car to more sustainable transport modes.

Concerning knowledge, it is more important to focus on the convergence than on the amount of available (single) knowledge. For example, in Europe, knowledge about negative consequences of traditional car use is now widely shared but, by itself, it is not sufficient to induce a modal shift and to distinguish between commuters' behaviour. In the transport sector the knowledge convergence can help to overcome a lack of information or misinformation, sharpening the awareness of the effects of one's behaviour, thanks to a clear view of the system and how it works. The drawback is the lack of data concerning users' knowledge crossed with life situations in the traditional travel surveys. At present, knowledge can help in explaining modal choice between alternatives with non-noticeable effects, such as the use of electric vehicles or modal choice for long-distance trips.

Focusing on goal-like values (e.g., independence, excitement, respect for the environment, etc.) or assessing them indirectly through, for example, the identification of rewarded or sanctioned behaviours (as proposed by Oyserman [45]) may highlight the strong influence of values on modal choice. While values are more related to general attitudes, they are not sufficient to obtain a real modal shift even though they have an influence on travel behaviour while specific attitudes and beliefs better predict behaviours than values or general environmental concerns [35,46]. The study of role of values as regards travel behaviour has shown that the social value orientation of cooperation is positively correlated with self-transcendent values, such as equality, social justice and solidarity [47]. Concerning their influence on travel behaviour, self-transcendence, social cooperation and eco-centrism values seem to positively correlate with a decision to favour public transport over car [48] and with a greater wish to reduce car-use [33].

Although post-materialism has never been studied in a transport context, it is not clear if its values are able to explain pro-environmental behaviour—at least in the Western countries [32]—or policy support [49]. The risk perception, known as cultural theories or "myths of nature", studied by Steg and Sievers [10], shows that people adopting an ephemeral point of view were more aware of car-use problems and more favourable towards supporting car reduction policies. The myth of nature has been related to the general environmental concern measured by the New Environmental Paradigm scale (NEP) [50], which assesses—on one dimension—the propensity of people to adopt or support pro-environmental behaviours.

The influence of religious orientation on pro-environment behaviour is considered positive by Kearns [51] but the opposite has also been argued [52]. Indeed, empirical research shows some contradictory results [53,54], due to the complex interactions between religious beliefs, political orientation and environmental concern, as explained by Sherkat and Ellison [11]. These authors argue that Protestants are more willing to accept a personal pro-environment behaviour but, being influenced by conservative stances on the seriousness of risks, they give little support to environmental activism.

The New Environmental Paradigm scale [55] has now become the main tool to assess people's ecological worldview and it is a good predictor of environmental attitudes and behaviours [56].

Worldviews, together with values, can be used to better specify the behavioural models as predictors of attitudes towards mobility but they have to be related to specific situations and contexts. They are less powerful than values in inducing modal shift. Instead, they are more related to the adoption of a certain lifestyle that can induce a "mobility style" (e.g., pro-bike or pro-public transport).

Norms usually have a small, albeit significant, role in explaining pro-environmental behaviour (e.g., [34,57]). This may be due to the way these constructs are assessed in most questionnaires, where items measure salient and explicit norms (people tell you what should be done). In contrast, implicit prescriptive and descriptive norms may play a crucial role, notably in driving behaviour or in explaining behavioural differences in cross-cultural research. This aspect has been observed by referring to the use of public transport by a community of Iranian students in Italy. The mix of social classes using public transport in Italy induced the Iranian students to consider it worthy of use instead of cars, changing their perspective about the social status of those using public transport [58] and making it socially acceptable. The same applied for the use of the bicycle; peers behaving in sustainable modes induced a behavioural change and showed that norms can be good predictors of travel behaviour.

Even though in the transport sector the concept of personality traits has probably been oversimplified, lifestyles and personality traits have been used to cluster the typologies of travellers. However, these typologies do not seem related to any accepted psychological definition of personality traits. Anyway, an increased use of lifestyle and personality traits in behavioural models could help to understand travellers' preferences and find out which trait/s can be worth investigating in the travel survey to better predict travel behaviour. Hilderbrand [59] used socio-demographic variables to cluster elderly people in six lifestyle groups and used these clusters to run a micro-simulation of an activity based model. A series of studies tried to investigate the role of personality traits: Mokhtarian, Salomon and Redmond [60] defined four typologies (adventure seekers, organizers, loners and calm people) thanks to a 17-item questionnaire and Cao and Mokhtarian [61,62] used an 18-item questionnaire that again individuated four lifestyles. Findings showed that adventure-seekers travel the most and are more flexible and that they tend to consider a wider set of strategies to reach their personal travel interests [63]. Anable [64] proposed five typologies—die–hard drivers, car complacent, malcontent motorists and aspiring environmentalists—which unite car dependence research with pro-environment concerns.

Modal choice is strongly linked with personal and collective sensibility, emotions and personal stories. The affective dimension tying some people to their car is not only a psychological factor but is generated by collective cultural and symbolic patterns [36,37]; such aspects were understood very

early on by manufacturers, who developed emotion-targeted advertisements. In transport research, emotion as an explanatory variable of modal choice is measured in terms of anticipated emotions, that is, thoughts about future feelings after attaining a specific goal (see [20–22]). Emotional response shortcuts rational decision-making and past experience; notably, contact with nature at an early age explains pro-environmental orientation. The more people were used to living in close relation with nature in early age, the more they participate in active environmental citizenship [23]; thus, significant life experience can lead to environmental sensitivity and support to environmental policy. Pronello et al. [65] showed that the direct observation of air pollution effects on children's chronic respiratory disease could explain, by itself, the choice of a sustainable travel mode. Gobster [66] argued that people prefer landscapes showing the most damaged ecosystem, due to a biased vision of nature, perceived as a means to attain a certain useful result [3]. However, such a preference is challenged when considering that the motor vehicle evolved from utilitarian use to an "object of desire" and many people would admit how well they feel while immersed in a natural environment, driving a car on rural roads in the middle of fields.

Empirically, attitudes were thought to be aligned with behaviours; inconsistencies between attitude and behaviour spurred the search for moderators of the effect of attitude on behaviour, namely intention and Perceived Behavioural Control (PBC). Attitudes have been successfully used to segment users to better predict their travel behaviour (e.g., [35,46,64,67–72]).

Habits in transport research are usually intended as travel patterns repeated over time, whose strength is often measured through the frequency of past behaviours [73,74]. In traditional transport economic models, habitual patterns are often implicitly accepted without questioning their validity [75]. However, habits and past behaviour explain the acquisition of biased information between alternatives but are not explanatory per se. More than the role of past behaviour in decision-making, our concern shall focus on the mechanism behind habit evolution and transformation of the modal choice.

3. Review of Main Behavioural Theories Explaining Behaviour and Pro-Environment Behaviour

The psycho-social variables described in Section 2 may contribute to explaining individual behaviour and, as shown in Figure 1 and reported in Table 2, some of them could be easily and successfully used to forecast travel behaviour, improving its prediction. However, measuring the variables better fitting the transport sector it is not a trivial task, especially since overlapping concepts and ambiguous definitions are often encountered, leading to contradictory results. This holds true when trying to understand and predict human decision-making processes: in fact, entanglement, reciprocal moderations or enhancement, or nonlinear relationships between factors and behaviour have to be taken into account.

As regards the transport field, in the early 90's, a shift was observed from the empirical correlation between variables and behaviour towards the construction of theories, psycho-social constructs and causal processes generating the behaviour [67].

A large number of theoretical frameworks have been developed over the years in order to capture the factors leading to decision-making or behavioural choices. We selected the most relevant theories that have been used to more broadly explain pro-environment behaviours, and, for some of them, to specifically expound modal choice or modal shift from the environmental psychology literature. Such theories are based on correlational evidence and, as such, have similar properties. We can define three different groups of theories in behavioural research, namely (1) ***individual-focused theory of decision-making***; (2) ***individual-focused theory of behavioural change***; (3) ***community-focused theory***. In Table 2 the overview of such theories is presented, describing them and providing the related references while Sections 3.1–3.3 analyse them in relation to the psycho-social variables they use. Section 3.4 finally presents the strengths and weaknesses of the application of such theories to the transport sector.

3.1. Individual-Focused Theories of Decision-Making

Individual-focused theories of decision-making represent the largest part of psycho-social studies applied to transport research; among the most significant are the *Theory of Planned Behaviour* [15], the Theory of Interpersonal Behaviour [25], the Norm Activation Theory [13], the Value-Belief-Norm theory [49,76] (Table 2).

The ***Theory of Planned Behaviour*** (TPB) is most likely the best-known behavioural theory in transport research, environmental psychology and health related studies. It is, in turn, acclaimed for its great success and remarkable predictive power in empirical studies [77] or profoundly criticised and utterly disregarded [78]. Through years of widespread applications in many fields, it has been modified and many variations exist in literature; researchers have added more variables to try to more accurately predict future behaviour: anticipated emotions [79], perceived mobility needs [80], personal norms [34]. Furthermore, Conner and Armitage [81] proposed to add six variables to the initial model: (1) belief salience; (2) locus of control, that builds up the perceived behavioural control together with self-efficacy; (3) moral norms; (4) self-identity, that expresses the recognition of the potential and qualities of the individual to cover his/her societal role; (5) affective beliefs, anticipated emotions or regret; (6) past behaviour/habit.

Trying to reinforce a theory explaining reasoned (or planned) behaviour by adding "habits"—a non-deliberative variable—risks becoming an auto-destructive idea. It is clear from Figure 2 that such additions would lead to a model closer to the Theory of Interpersonal Behaviour (TIB) than to the TPB. In fact, the ***Theory of Interpersonal Behaviour*** (TIB) by Triandis [25] shows great similarity to Ajzen's TPB; both theories aim to explain intention to engage in a certain behaviour and to perform such a behaviour. In TIB, however, intention is not only driven by personal cognition (subjective norms [SN] and attitude [ATT]) but also by emotions (affective constructs), social norms and self-identity (social constructs). Moreover, habits play a direct role in explaining behaviour; Triandis [25] argues that automatic performance of a behaviour decreases the level of conscious control over such behaviour. Finally, whereas in the TIB the presence of objective external restriction in performing a behaviour has a direct effect, the TPB assumes a subjective representation of those factors influencing intention.

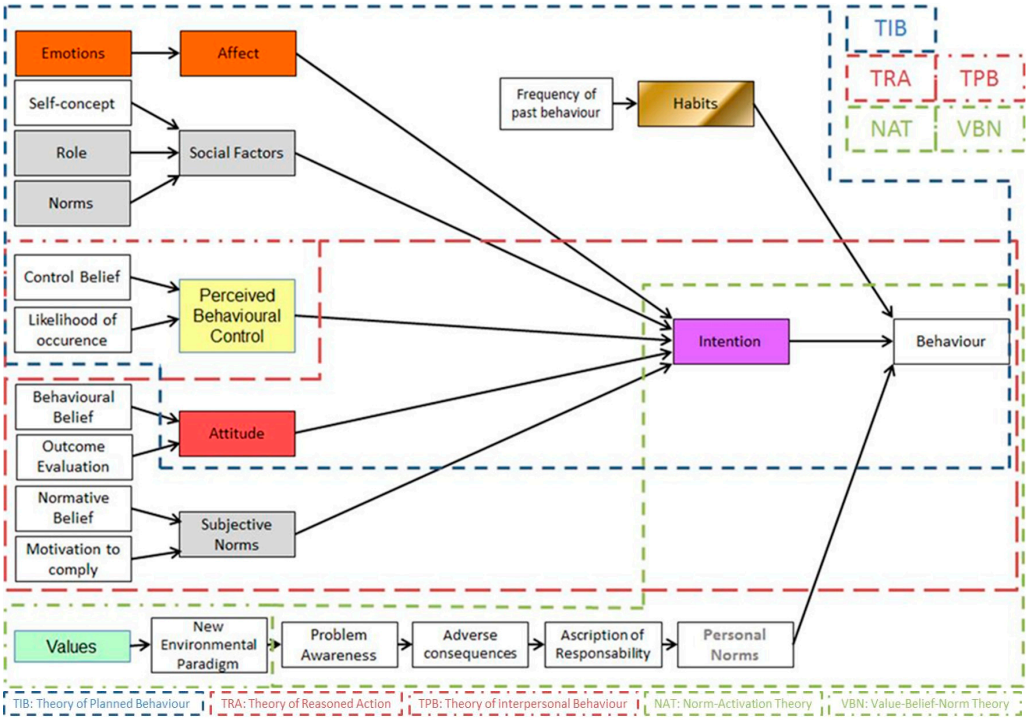


Figure 2. Similarities and differences among individual-focused theories of decision-making.

Table 2. Overview of selected behavioural theories.

Approach	Theory	Description	References
Individual-focused theories of decision-making	Theory of Planned Behaviour (TPB)	It is an extension of the Theory of Reasoned Action (TRA) [41], developed to understand the relationship among attitudes, behavioural intention and actual behaviour. It states that behaviour depends on both motivation (intention) and ability (behavioural control) and proposes six constructs that collectively represent a person's actual control over the behaviour: three types of beliefs (behavioural, normative and control), attitudes, subjective norms, perceived behavioural control.	[15]
	Theory of Interpersonal Behaviour (TIB)	It shows that behaviour in any situation is a function of the intention (influenced by social and affective factors as well as by rational deliberation), habitual responses, situational constraints and conditions. Behaviour is influenced by moral beliefs but the impact of these is moderated both by emotional drives and cognitive limitations.	[25]
	Norm Activation Theory (NAT)	It describes the relationship among activators, personal norms and behaviour. Norm activation refers to a process in which people construct self-expectations regarding pro-social behaviour. These behavioural self-expectations are called "personal norms" and are experienced as feelings and moral obligations. Four situational factors (situational activators) and two personality traits activators are key in the process of norm activation.	[13,82–84]
	Value-Belief-Norm theory (VBN)	It states that individual choices about pro-environmental actions can be driven by personal norms. Such norms are activated when an individual believes that violating them would have adverse effects on what (s)he values; furthermore, by taking action, (s)he would bear significant responsibility for the consequences of his/her choices. Personal values (e.g., altruistic and egoistic values) are antecedents of environmental beliefs.	[76]
Individual-focused theories of behavioural change	Trans Theoretical model (TTM)	It is an integrative, biopsychosocial model to conceptualize the process of intentional behavioural change, seeking to include and integrate key constructs from other theories into a comprehensive theory of change that can be applied to a variety of behaviours, populations and settings (e.g., treatment, prevention and policy-making settings, etc.). One of the key constructs of the TTM is the Stages of Change: pre-contemplation, contemplation, preparation, action, maintenance.	[85,86]
	Stage model of Self-Regulated Behavioural Change (SSBC)	It assumes that the temporal path of behavioural change can be broken down into four independent, qualitatively different stages: predecisional, preactional, actional and postactional. In each of these four stages a person is confronted with solving a specific task in order to successfully change her/his behaviour	[22]
	Protection-Motivation Theory (PMT)	It was originally proposed by Rogers (1975) and later revised (1983), stating that the intention to protect oneself depends on four factors: (1) the perceived severity of a threatened event (e.g., a heart attack); (2) the perceived probability of the occurrence, or vulnerability; (3) the efficacy of the recommended preventive behaviour (the perceived response efficacy); (4) the perceived self-efficacy (e.g., the level of confidence in one's ability to undertake the recommended preventive behaviour)	[87]
Community-focused theories and Social Interactions theories	Social Cognitive Theory (SCogT)	It states that learning occurs in a social context with a dynamic and reciprocal interaction of the person, environment and behaviour, emphasising the social influence and its external and internal social reinforcement.	[88]
	Social Comparison Theory (SCompT)	It deals with how a person forms beliefs and opinion about his or her own capabilities. Human beings tend to assess their opinions and to know more about their abilities; when they are unable to evaluate their opinions and abilities, they tend to compare themselves with others.	[89]

The ***Norm-Activation Theory*** (NAT) [13] was first developed as a model for explaining altruistic behaviour. The rationale is that pro-social behaviour depends on the activation of personal moral norms, which are triggered once individuals expect a negative outcome to a given situation (problem awareness [PA] and adverse consequences [AC]) and when they believe their action may have a role in reducing this threat (ascription of responsibility [AR]). It seems that there is confusion among researchers about how to interpret the causal relationship between the variables: at least three approaches have been proposed in the literature to deal with such variables: (1) the relationship between Personal Norms (PN) and Behaviour is moderated by Problem Awareness (PA) and Ascription of Responsibility (AR) [90,91]; (2) Problem Awareness (PA) influences Ascription of Responsibility (AR), which in turn influences Personal Norms (PN) and PN influence behaviour [32,49,92,93]; (3) both Problem Awareness (PA) and Ascription of Responsibility (AR) influence PN, while PN, in turn, influence behaviour [67,94]. The first interpretation refers to a moderator model, while the other two interpretations imply a causal or mediation model. In a series of studies, De Groot and Steg [95,96] compared all three models and found most consistent support for the second one, which is represented in Figure 2. Moreover, they adopted an experimental design that supports a causal relationship between the variables.

More recently, Stern proposed to include values and worldviews in Schwartz's Theory [76]; he constructed the ***Value-Belief-Norm Theory*** (VBN) to explain environmentally significant behaviour through a causal chain from stable general values and beliefs to specific behavioural norms. The idea is that a specific behaviour will comply with a subjective norm only if it is not inconsistent with one's own personal values.

3.2. Individual-Focused Theories of Behavioural Change

The approach, focused on behavioural change, includes three main theories: the *TransTheoretical Model*, the *Stage model of Self-Regulated Behavioural Change* and the *Protection-Motivation Theory* (Table 2).

Firstly developed in the field of health-related behavioural changes, such as refraining from smoking, doing exercise, adopting a low-fat diet or using condoms, the ***TransTheoretical Model*** (TTM) is a model of intentional change, introducing the temporal dimension of change: while behavioural change was previously analysed as an event, the TTM recognises it as a process involving five stages—Pre-contemplation, Contemplation, Preparation, Action and Maintenance—and different processes, or activities, in which people engage to overcome difficulties encountered through the stages. These activities involve, for example, emotions, cognition, behaviour, social support or information gathering. The theory states that the effectiveness of a process/activity depends on an individual's position towards change; it is considered as a theory of ideal change, due to strong criticism towards the arbitrary threshold of stages [97], the nonlinear patterns of progression through stages [98,99] and the lack of effectiveness of interventions using TTM framework [100]. For a detailed discussion about the pros and cons of the model, refer to Armitage [101]. The TTM, as a model of voluntary behavioural change, has been rightly applied to consumer behaviour [102]. Bamberg [103] adapted the TTM to develop the ***Stage model of Self-Regulated Behavioural Change*** (SSBC), sometimes referred to as MaxSem model [104,105], for proposals on personal travel plans focusing on car-use. Interestingly enough, Bamberg [103] retained four stages, by combining preparation and action, that are identified from constructs taken from both Ajzen's TPB and Shwartz's NAT. This approach is in line with Armitage and Arden [106], although they argued in favour of TPB over TTM in furnishing tools for behavioural change. Bamberg et al. [22] support their voluntary behavioural change approach, which is obviously limited in range for a systemic change; however, they point out and we share their view, that stronger and wider empirical evidence is required to prove the efficiency of this model promoting sustainable transport. The ***Protection-Motivation Theory*** (PMT) [87] sets out a framework to develop and evaluate persuasive communication as well as a social cognition model to predict health behaviour. The origins of the theory lay in the study of the persuasive impact of fear on attitude and behaviour [107] initially undertaken through the ***Health Belief Model***, from which PMT derives.

The theory postulates that behavioural intention—here named protection motivation—to perform the recommended behaviour is assessed through a process of both threat and coping appraisal. Threat is supposedly determined by the assessment of both the severity of the threat and the likelihood of being directly affected by it. On the other hand, the coping appraisal is driven by the evaluation of the efficacy of the recommended behaviour on limiting the threat and individuals' ability to perform the recommended behaviour. Kim, Jeong and Hwang [108] used the PMT together with Fishbein and Ajzen's TRA to predict pro-environmental behaviour with relative success.

Figure 3 shows the similarities among the three theories related to the behavioural change, highlighting how the TTM and SSBC are very close to each other, aggregating the stages in a different way while PMT gives fear (and hence, emotions) as well as threat and coping appraisal as the main motivators of behaviour. All those theories consider self-efficacy as an important factor, at the end of the stages for TTM and SSBC (maintenance and post-actional) and as precursor of behaviour for PMT, more in line with community-focused theories (SCogT, see Section 3.3).

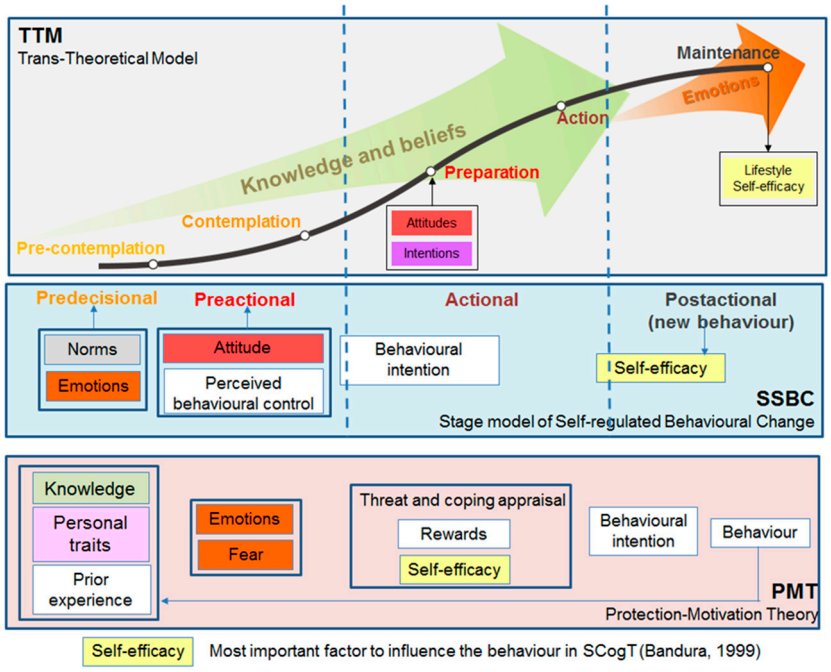


Figure 3. Similarities and differences among individual-focused theories of behavioural change.

3.3. Community-Focused and Social Interaction Theories

The ***Social Cognitive Theory*** (SCogT) [88] rejects the assumption that a behaviour is led by a stimuli-response phenomenon, making people act in a mechanical way, like for example, computing information to choose the best alternative in accordance to self-stated rules of decision-making. According to Bandura, people are seen as agents interacting among themselves, having expectations about the future, being influenced by environmental considerations and prompted to self-reinforcement and adaptive behaviour. People learn by doing, by observing others and they can modify the reality; thus, the human mind is "generative, creative, proactive and reflective, not just reactive" ([88] p. 157). According to SCogT, the most important influential factor of behaviour is self-efficacy, or confidence in their own capacity to attain a goal. This goal is defined thanks to outcome expectations (at different levels) and socio-structural factors (the environment that can facilitate or impede a given achievement). It is then assumed that the goal, expected outcome and self-efficacy itself can predict behaviour. No studies have been found applying SCogT either in the transport sector or in pro-environmental behaviour, while a lot of research encourages the use of SCogT framework as a theory-based intervention to promote healthy behaviour.

Festinger's ***Social Comparison Theory*** (SCompT) [89] states that when someone has no hint about how to judge or to act, (s)he will compare him/herself with most similar individuals and tend to adapt and reduce the gap between his/her own and others' behaviour. This is a direct implication of descriptive social norms, viewed as a dynamic process towards an asymptotic goal instead of a static injunction of what should be done.

The common element in the theories described in Figure 4 (explaining the comparison with other individuals) is represented by the "environment" in SCogT theory and by "evaluation" in SCompT theory. In the community-focused theories, there emerges an aspect common to the individually-focused theories: this is that all theories refer to individuals, since they all deal with "personal characteristics".

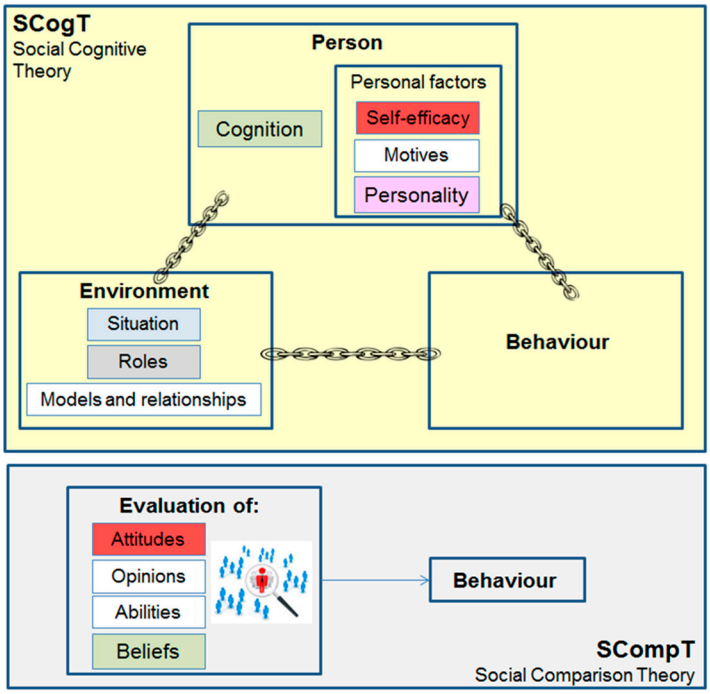


Figure 4. Similarities and differences among community-focused and social interaction theories.

Moreover, in individual-focused theories, the comparison with other individuals is implicitly included in the variable "norms". In fact, "social descriptive norms" are based upon observations of "what people do", which implies people watch others and act on the basis of what they do. Table 1 (grey section related to norms) shows the example of Iranian students acknowledging that, after observing other individuals on the bus, they changed their own behaviour, in regard to personal norms, adapting them to those of the others, "according to the rule": if somebody of a status higher than my own uses the bus, I should do likewise. They modified their perception of bus use in their own country, where just poor people and the immigrants resort to public transport.

3.4. Strengths and Weaknesses of Application to Transport Sector of Behavioural Theories

The individual-focused theories of decision-making represent an alternative to the classical economic approach to decision-making based on utility maximisation. TPB and TIB have both strengths and weaknesses, the latter having already been analysed adding new constructs in the model. The adaptations of TPB in the transport sector are several as discussed in Section 3.1. A development of TPB and TIB, based on alternative theoretical concepts and psychometrics of attitudes, intentions and norms may produce interesting insight. The best use of these theories in the transport sector lies in the modal choice where the use of attitudinal variables could largely improve modal choice models.

Furthermore, the collection of data related to users' attitudes would be even more important in market segmentation studies, providing more elements for a better forecast of modal choice. Instead, NAT and VBN are operationally too simplistic (or too focused on pro-social behaviour) to explain modal choice.

The individual-focused theories of behavioural change are largely empirical and originate from health-related studies. They postulate that change is driven by the level of risk or threat that could occur in a do-nothing situation, integrating knowledge and values into the change process. The usefulness of these frameworks of behavioural change for the forecast of modal shift is low, also in the long-term. The main problem of the application to the transport sector lies in the absence of perceived risk related to the modal choice, in the short-term and in the inability to imagine the consequences (in the distant future) related to the modal choice. Even though there is an increasing amount of information available and several campaigns have been launched to raise awareness about the health risks associated with air pollution (and notably by transport), particularly when the pollutants' thresholds are exceeded (frequent in some EU countries during the winter season), transport is not perceived as an ailment. Thus, only interventions enforced by law prevent people from using the car.

Conceptually powerful, the community-focused and social interaction theories represent the social formation of reality. They could be useful in a research-action context, or participatory intervention on a defined social and cultural context (e.g., living labs, educational contexts). Their application to the transport sector could be related to the analysis of large-scale behavioural change. In fact, transport entails social as well as individual issues, the latter generating the incentive to induce the social change. For example, if a person often uses the car, (s)he can understand that (s)he contributes to pollution, damaging others as well as her/himself; if the others often use the car, as (s)he does, (s)he realises that they damage her/himself, as well as themselves. This situation where no-one wins could spur a sort of reciprocal control and social comparison that could induce a (slow) behavioural change.

Table 3 presents a final synthesis of potential advantages and shortcomings of the above theories.

Table 3. Synthesis of advantages and shortcomings of the selected behavioural theories.

Behavioural Theories	Advantages and Shortcomings
Individual-focused theories of decision-making	Very versatile. Useful to explain relationships among variables. Wide-spread modelling tools, based on multivariate statistics. Decent predictive power for simple modal-choice usually embedded into repetitive pattern.
Individual-focused theories of behavioural change	Interesting as an exploration of mid to long-term processes of change. May highlight the dynamics of mind, the stability of motivation, or the evolution of the relations between psychological constructs. Not general enough for direct application in transport sector. Mainly descriptive.
Community-focused theories and Social Interactions theories	Reveal emerging phenomenon inside complex systems. Modelling thanks to social networks or agent-based techniques—rarely robust. Highlight the greater effect of behavioural convergence through social norms. Never applied as a theory-grounded intervention.

4. Discussion

It is unlikely that scientists will one day be able to untangle the complexity of the human mind: (a) taking into account all possible factors prompting one person to act in a certain way; (b) taking into account, at the individual level, both endogenous variables (from real-time information gathering to lifelong memories and unconscious decision-making processes) and exogenous variables (from particular weather conditions to normative demands).

However, several methodological tools and models have been developed to forecast human behaviour, as shown in Section 3, mainly based on psychological theories. Looking at Figure 1 and Table 1, by reporting the main psycho-social variables influencing behaviour and, notably, pro-environment behaviour, we can observe that all those variables are used in both individual-focused

and community-focused theories (Table 2, Figures 2–4); the difference is the way in which they are considered in relation to the individual. If we think that human behaviour (and notably pro-environment travel behaviour) is related both to individual and social characteristics and that taking decisions may breed an interaction with others (social aspect) and prompt potential change, the models should bring all these different issues together to better predict behaviour. An approach like the one shown in Figure 1, integrating the variables related both to the individual and to the social interaction in one framework, could perform well in transport because, in travel-related choices, not only is the individual side significant but, likewise, the social one (e.g., interaction with others when using public transport instead of a personal car). However, so far, the models most commonly used to forecast travel behaviour are stochastic (discrete choice models), based on theory of the maximum utility that relies on individual benefit (individualism and eco-centrism). Furthermore, such models, calculating the probability that an event will happen (and, hence, that an individual makes a certain choice), are based on the observation of the occurrence of such event and they are neither able to understand the motivations behind the users' choice, nor to include psycho-social variables.

In psychology, the theory is needed to build measures of subjective mental states in response to questions about or observation of body movements, drawings and so forth. Furthermore, when constructing a theory based upon subjective psychological constructs, narratives are necessary to give sense to data because one can subjectively refer his/her own experience to what those narratives express. Thus, in order to support a theory, not only are data required: definitions have to be precise, concepts should be intelligible and cause and effects should be coherent with one's own pace of thinking. The development of a theory is not independent from the construction of psycho-social variables, as some of them are constructed ad hoc in order to support the narratives.

The complexity of interaction between alleged independent variables is largely underestimated. The causal chain that leads to decision-making, or behavioural intention, is hypothesised by the formulation of the theory and—the majority of studies being observational—our certainty about the direction of causality is inexistent. Thus, regularity models of causation—based on observational phenomena and data—whose first theorist was the philosopher David Hume (An Enquiry into Human Understanding, 1751), have been abandoned in favour of counterfactual models. Those models define causation in terms of a comparison of both observable and unobservable events. Structural equation modelling (SEM) is one of prominent approaches to causal inference using counterfactuals, based on the work of Judea Pearl [109].

Hidalgo and Sekhon [110] notice that modern advocates of structural equation modelling (SEM) argue that it "does not explicitly take into account knowledge about the mechanisms linking background, independent and dependent variables" (p. 209). Thus, SEM does not model causality in relation to experiments but sets up a causal model of the analysed relationships through a system of structural functions so that "hypothetical interventions should be explicitly and formally related to the causal mechanisms under study". In this way, the use of SEM as a method to derive causality from observational data could be misleading because the aim of the SEM is to support a narrative to explain the causality and too much is left to the researcher's assumptions, often insufficiently discussed. Feedback loops or non-linear relationships are mostly unexplored. Can we really claim that a positive attitude towards cycling will lead someone to ride rather than being a consequence of it? The question is not new: Bandura [111] regretted that most psychodynamic processes are inferred by the behavioural response they ought to explain.

In psychology, the measurement of psycho-social constructs, such as attitudes, norms, affects and so forth, is mainly performed under the paradigm of Classical Test Theory. Practically, as it is assumed that internal states of mind are unobservable, the variables of interests are determined through the use of questionnaire items: a latent factor that will capture the covariance of different items is constructed. However, the validity of measures of unobservable variables depends on the strength of their concept and on the ability of items—carrying their own measurement error—to reflect a specific psychological construct without accidentally measuring an outside variable. Applying complex

correlational models (such as the SEM) to data necessarily leads to the multiplicative invalidity problem [112], where relationships among unobserved variables may be illusions created by the multiplication of measures errors.

In several studies, inferences are generally of poor quality and, pretty often, only reflect the researcher's thoughts due to the way questions are asked. Some issues closely related to correct data interpretation are given here as explicit: we lack univocal definitions of psychological constructs; we often lack conformity between measures and behaviour (Ajzen's compatibility principle); many common modulating factors, both internal (ambiguity of ecological attitudes) and external (peer pressure, context such as costs, built environment and normative system) are not accredited by the theories; when measuring past behaviour to predict future behaviour, are we sure we are not measuring the same thing ? This aspect also raises the problem of the questions which arise when looking ahead, because the literature clearly shows a lack of longitudinal (before/after) studies. Are we aware of the mathematical implications of our model and statistical analysis? Too often questions of mutual causality and the validity of linear response are overlooked.

Chorus, Molin and Van Wee [113], clearly showed in their meta-analysis that the expected effects of travel information are below expectations although they may be effective in some specific cases. Hunecke, Haustein, Grischkat and Böhler [114] used a hierarchical regression analysis to assess the effects of psychological variables when socio-demographic and infrastructures are controlled. They concluded that, in terms of ecological impact, the measured psychological variables were responsible for an additional 14% of explained variance (reaching 60% of total variance); this clearly shows that our understanding of the effect of psychological factors on travel behaviour is very low and we probably still miss key factors that could improve our understanding.

However, behavioural research points out the existing gap between the measured attitude, the measured behavioural intention and the observed behaviour. This inconsistency between what people say and what people do is referred to as the attitude-behaviour gap [115,116] or the intention-behaviour gap [117,118], demonstrating the volatility of the concepts of attitude or intention. Mostly attributed to information deficit, which refers to the level of knowledge about behavioural consequences or, in a more tangible way, to the existence and to the characteristics of possible alternatives, such a gap poses a real problem for any policy maker. When attitudes and behaviour are inconsistent, which is called cognitive dissonance [119], individuals are more likely to change their attitudes instead of behaviour, in many ways [120]. Tertoolen, Van Kreveld and Verstraten [121] showed that making the gap between attitudes and behaviour more obvious could entail undesirable consequences defined as social dilemmas and the unwillingness of people to change their habits.

Moreover, there is clear confusion about measuring psychological constructs at a specific level (e.g., attitudes towards the use of public transport to commute) or at a general level (e.g., attitudes towards alternatives to cars for mobility needs). Taking the example of NAT applications, some researchers measured the various model variables on a general level [49,92], while others measured them on a specific level [33,93,122]. Pronello and Camusso [35] used both specific and general attitudes to segment the market.

Adding complexity in the behavioural theories will not, arguably, solve the gap between attitude and behaviour, while a deeper understanding of travel behaviour requires a redefinition of the concepts (attitude and habits) and a comprehension of how such concepts and psychological constructs are understood. In an article recalling a historic debate, Kaiser, Byrka and Hartig [123] stated that "the attitude-behaviour gaps are empirical chimeras" (p. 351). They give a paradigmatic answer to many of the problems cited above using Campbell's definition of "behavioural disposition" [124]. Within this concept, attitude and behaviour are ideally perfectly connected through a "behavioural disposition", making the "blurred" causal relationship unnecessary. Attitude towards a given object is only person-dependent and reflects itself through a set of behaviours transitively ordered according to the level of difficulty (cost) to perform them: in practice, attitudes are measured by means of what people do, not of what they say. With such a Campbellian measure of attitudes, as explained

by Kaiser and Byrka [125] (p. 26), "there is no room for hypocrisy": people put their general attitudes into specific attitude-relevant practices and differences in people's general attitudes can be derived from their attitude-relevant behaviour. Indeed, we can consider that a bike commuter shows a higher behavioural disposition to cycling than someone who states that (s)he is feeling good, feels loved and is encouraged by peers to use the bike. This implies that answers to a given set of behaviours, defined by the researcher, are direct projections of latent attitude on real behaviours. Our logic in every-day actions is constructivist: our beliefs, knowledge, habits, desires are derived from our past experience, learning skills and capacity to adapt. As argued by Smith and Conrey [126], social psychologists should be interested in studying theories through the lens of *interactions amongst individuals*, instead of expressing them as relationships among variables. Despite success in a wide variety of fields, social simulations are far from obtaining global consensus in the scientific community. However, they seem a useful and promising tool that social scientists need to describe and understand the real-world.

Concerning habits, Schwanen, Banister and Anable [127] initiated a philosophical discussion about our understanding of how those habits are developed and perceived. It is doubtful whether past-behaviour (or habit strength) properly explains future behavioural intention. However, unsurprisingly, past behaviour has been successfully used as a predictor of both behavioural intention and behaviour itself, at least when the context is stable [73,128] and may represent the main obstacle to behavioural change [26,129]. However, Schwanen et al. [127] (p. 524) observed that "*both dependent and independent variables may well be measuring one and the same thing—A general tendency to perform the behaviour in question*". Taleb [130] showed how past facts (historical time series) are not good predictors of the future and pointed out the fragility of our knowledge, so that predictions based on past knowledge seem by far less useful than a continuous adaptation and adjustment to unpredictable events.

5. Recommendations and Conclusions

To improve the prediction ability of models, it is necessary to investigate the hidden motivations and to understand what the variables to analyse and, hence, the data to collect are. But human beings are complex and too many variables interact in their choice processes; furthermore, they are social beings and this fact cannot be ignored when trying to predict their choices particularly when related to their travels. Their trips characterise them as social beings (altruism) or as individuals (egoism) and the choice of transport mode, for example the car, can enhance their individualistic side (boost of ego) while public transport puts them in relation with others, confronts them with others and induces comparative self-assessment. What does a change in behaviour imply? It implies changing the image we have about ourselves, reassessing it in light of the new behaviour, coming out of our "comfort zone" (see the case of Iranian students in Section 2.1).

The observation of the continually evolving reality seems to be a better approach, made possible thanks to new technologies (sensors, smartphones, etc.) allowing massive data collection that, combined with context-specific understanding of human behaviour and analysed thanks to appropriate mathematical and statistical tools, could provide "*powerful insights about the different ways people interact with one another*" [131]. For sure, a paradigmatic change in data collection is a necessary further step towards understanding human behaviour and resolving the attitude-behaviour gap. Indeed, it is difficult to get a general picture of the mobility determinants that should be included in the transport models through the travel surveys—similarly to that related to the socio-economic variables—but thanks to the big data and social networks such information will be more and more available, supporting the data coming from attitudinal surveys. However, psycho-social variables will make the difference in the transport models only when the psycho-social theories will have gone beyond the limits described in this paper.

To this end a true interdisciplinary approach, bringing together transport science, artificial intelligence, behavioural and social sciences by addressing a series of gaps in transport planning and their impact on the development of contemporary cities seems necessary.

We believe that agent-based social simulation could be a key tool to understanding to what an extent both cognitive processes (Sections 3.1 and 3.2) and interpersonal interactions and social behaviour (Section 3.3) can reproduce empirical results of the complex and dynamic system that urban transport is. Even unrealistic social simulations can give us some interesting clues about the importance of the threshold effect, feedback loops, emergent phenomena, crowd behaviour or dynamic equilibrium.

After more than 25 years of fruitful psychological studies on travel behaviour, it seems that we now have a better understanding of the cognitive processes behind modal choice but we have not yet understood the mobility related dynamics and, unfortunately, we have not yet been effective in leading people towards a more sustainable mobility: nowhere in the world have researchers really succeeded in implementing a sustainable transport system, in terms of infrastructure, activity re-localisation or behavioural shifts. We have gained insights about what drives behaviours but the real interest still remains unclear: what is the way to achieve massive car-use reduction, which policy may have a significant impact [132] or how to use fear-driven communication in order to influence behaviour, as is often done for health-related issues. Definitely, failing to trigger sustainable mobility has and will have harmful effects on our lives. Policy makers should take responsibility for activating risk perception through education, advertising and so forth and with the support of different disciplines.

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