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Abstract: The transport sector creates much environmental pressure. Many current policies aimed at reducing this pressure are not fully effective because behavioural aspects of travellers are insufficiently recognised. Insights from behavioural economics can contribute to a better understanding of travel behaviour and choices, and the impact of these on policies. Few studies have examined this issue. We review these and provide a broader, more encompassing perspective on environmental policy focused on transport, and taking into account bounded rationality as well as social preferences.

Behavioural economics, travel behaviour and environmental-transport policy

Abstract

The transport sector creates much environmental pressure. Many current policies aimed at reducing this pressure are not fully effective because behavioural aspects of travellers are insufficiently recognised. Insights from behavioural economics can contribute to a better understanding of travel behaviour and choices, and the impact of these on policies. Few studies have examined this issue. We review these and provide a broader, more encompassing perspective on environmental policy focused on transport, and taking into account bounded rationality as well as social preferences.

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JEL classification: R40, R48.

1. Introduction

Key challenges in attaining sustainable urban travel behaviour include physical-infrastructure, technological and behavioural issues. There is an ever growing number of studies noting that a transition to sustainable mobility is unlikely if technological improvements and changes in the built environment are not combined with behavioural change (Avineri 2012; Metcalfe and Dolan 2012; Steg and Vlek 2009). Many studies have tackled these issues focusing on particular policy strategies (e.g., physical planning and infrastructure supply, pollution standards, pricing mechanisms and information provision), but have in most cases assumed representative, rational agents. However, behaviour of travellers is heterogeneous while their preferences are inconsistent (Anable 2005; Barr et al. 2011). Moreover, socioeconomic factors are insufficient to explain observed differences in behaviour.

Transport reality is often better described by behavioural approaches. They have already received some attention in recent studies on travel behaviour. Two themes of behavioural economics are encountered in travel studies. One is bounded rationality, addressed mainly by applying Prospect Theory to travel time uncertainty and interpretations of expected travel time, which is relevant to valuation exercises in project appraisal, notably understanding WTP/WTB differences in estimating the value of time savings (Avineri and Bovy 2008; Batley 2007; van de Kaa 2005, 2006; Schwanen and Ettema 2009). Several empirical studies aim to improve demand management by using real-time information about travellers in transport networks (Avineri and Prashker 2003; van de Kaa 2008; Nakayama and Kitamura 2000). This is of importance to re-distribute traffic and reduce congestion, which affects local air quality. Most of these studies adopt an experimental approach within controlled settings so that the effects of targeted factors can be analysed in isolation. Insights are then used to improve demand modelling.

A special issue within this theme of bounded rationality of travellers is that of habitual behaviour (Bamberg et al. 2003; Bamberg and Schmidt 2003; Gardner 2009; Klöckner and Matthies 2004; Thøgersen (2006); Verplanken et al. 1998). Habits reflect time-inconsistent preferences that lead to seeking immediate rewards. Most daily travel choices are largely habitual and automatic, involving low information processing (Verplanken et al. 1997). Habitual travel behaviour violates rational choice principles through the absence of a process of cognitive deliberation –involving preference formation, deliberate information processing and preference-based choice (Gärling et al. 2001).

The second theme is social preferences, which include altruism, fairness, norms, reputation and status seeking concerns. Social preferences have received most attention in studies explaining modal choice (Abrahamse et al. 2009; Anable and Gatersleben 2005; Johansson-Stenman and Martinsson 2006; Sohn and Yun 2009). There is a long history of applying social psychology to travel studies dealing with feelings of moral obligation, perceived social pressure and control beliefs.

In parallel, behavioural economics has recently seen much application to environmental economics. This has given rise to studies of sustainable consumption, voluntary cooperation in public goods like conservation of natural resources or recycling, environmental valuation, and the implications of these for environmental and climate policy (for surveys, see Brown and Hagen 2010; Gsottbauer and van den Bergh 2011; Jackson 2005; Shogren and Taylor 2008; and Venkatachalam 2008). These studies support the idea that explicitly accounting for behavioural biases due to both bounded rationality and social preferences, increases the understanding of complex environmentally-relevant behaviour, and so provides an improved basis for environmental policy design.

The present study reviews empirical evidence on behavioural biases in travel choices (long- and short-term choices) and their implications for environmental-transport policy. Van de Kaa (2008) and Li and Hensher (2011) offer a review of applications of Prospect Theory to transport policy, while Avineri (2012) and Metcalfe and Dolan (2012) offer broader surveys of the implications of bounded rationality and social preferences for travel behaviour and policy. However, none of these studies deals in detail with environmental policy issues related to transport, which is the focus of our review.

The remainder of this article is structured as follows. Section 2 offers a literature review of insights from behavioural economics that are applicable to travel behaviour. Section 3 discusses policy implications and provides guidelines for environmental-transport policy design. Section 4 concludes.

2. Behavioural economics and transport

2.1 Behavioural economics

Behavioural economics merges the fields of economics and psychology to provide a better understanding of choice behaviour (Camerer 1999; McFadden 1999; Rabin 1998). Realistic behaviour of individuals is often not well captured in traditional models of economic policy.

When choices are complex and involve probabilistic outcomes, individuals tend to use heuristics, establish false associations, or incur logical leaps due to mental shortcuts and calculation mistakes. These deviations from rational agent behaviour are due to imperfect information and individuals' limited computational abilities. On the other hand, how alternatives are presented (i.e., *framed*) influences choices, while individuals tend to exhibit choice persistence or inertia, so as to avoid possible losses, and make conservative choices when outcomes are framed as gains and risky choices when outcomes are framed as losses. These biases are a consequence of the asymmetric valuation of gains and losses, loss aversion, and probabilities being weighted non-linearly. Hyperbolic discounting (i.e., overvaluation of the present over the future), myopic behaviour, self-control problems and habit formation are due to immediate rewards being more heavily weighted than future gains, thus denoting time-inconsistent preferences. Finally, individuals show limited self-interest (e.g., altruism and fairness) and inter-dependency of choices due to social and self-identity concerns.

These biases create inconsistencies in behaviour that are generally classified under two broad categories, namely bounded rationality, and social or other-regarding preferences (Gsothbauer and van den Bergh 2011). Table 1 offers a summary of some of the various behavioural anomalies and systematic biases relevant to the transportation context.

[TABLE 1 AROUND HERE]

Systematic behavioural biases have implications for policy design. Indeed, several authors have translated insights of behavioural economics into general policy rules. Notable examples are NUDGE (Thaler and Sunstein 2008) –a mnemonic for **i**ncentives, **U**nderstand people's heuristics, use **D**efaults, **G**ive feedback information, and **E**xpect errors of judgement–, the seven principles from the NEF report (Dawnay and Shah 2005) –use of normative incentives, commitments, defaults, framing and heuristics, while taking into account habits and routines–, and MINDSPACE (Metcalfe and Dolan 2012) – a **M**nemonic for **I**ncentives, **N**orms, **D**efaults, **S**alience, **P**riming, **A**ffect, **C**ommitment, and appeal to **E**go–, the latter being focused on travel behaviour and transport policy. A difference between this study and Metcalfe and

Dolan (2012) is that we provide a more complete review of the set of travel choices (short- and long-term choices) and associated insights from behavioural economics, which allow resulting lessons for environmental-transport policy.

2.2 Application of behavioural economics to transport

Travel choices can be distinguished into long-term and short-term choices (Table 2). *Long-term choices* are not travel choices *per se*, but entail long-term commitments with strong determinants of daily travel behaviour, namely residential and employment locations and engagement with travel modes of the type of getting a driving license and car ownership. Such commitments have a lasting effect and constrain *short-term* or daily *choices*. A similar distinction is made in van de Kaa (2008). Figure 1 offers a summary of the empirical evidence on behavioural biases in travel choices.

[TABLE 2 AROUND HERE]

[FIGURE 1 AROUND HERE]

2.2.1 Long-term choices

Residential and employment location choices: Travellers express bounded rationality in their residential and employment location choices. They face imperfect information about job and residence offers, as well as incur both searching and transaction costs (pecuniary and non-pecuniary) that impede relocation and contribute to inertia (van Ommeren and Fosgerau 2009; van Ommeren and Leuvensteijn 2005; van Ommeren and van der Straaten 2008). The latter leads to the inefficient situation of having excess commuting (e.g., cross-commuting trips). Inertia in turn provides the stability necessary for habits to form and persist (Ouellette and Wood 1998). In choosing residence, the effect of price anchoring has been described in real estate market studies (Epley and Gilovich 2005). This effect is most clearly observed when people relocate to a new city, as they tend to go for the same price they were paying before, even when housing prices are lower in the new location (Ariely 2009). Choices further depend on the way alternatives are presented, known as framing. Studies by Tversky and Kahneman (1991) and Axhausen et al. (2001) support the idea that in choosing a job or a house, households take their prior status as a reference and thus value alternatives and their attributes in a loss-averse manner.

At the intersection of location choices and travel mode choices self-selection bias plays a role. Individuals may opt for car-oriented environments if they are inclined to drive, or choose pedestrian-oriented environments if they are committed to walking or cycling (Axhausen et al. 2001; Cao et al. 2002; Handy et al. 2005a; van Wee et al. 2002). Self-selection bias is found to have a greater effect in people who have relatively strong preferences for driving (Handy and Mokhtarian 2005).

Regarding the choices “obtaining a driving license”, “car ownership” and associated “car purchasing”, factors like emotions, status and norms can encourage engagement with the car. We consider these choices next.

Obtaining a driving license has a strong symbolic and emotional component, like a ritual of adulthood initiation. Haustein et al. (2009) report a high importance of symbolism and affective socialization constructs in the formation of driving habits and positive personal norms about

driving among adolescents. These constructs are learned from parents and peers who serve as role models, transmitting (pre-existing) social norms regarding car use.

Car ownership: Travellers commit themselves to particular travel behaviours through the ownership of cars and season-tickets for public transport; they accept a large one-off payment for low or zero marginal cost at the point of use (Simm and Axhausen 2001; 2003), and can incur mental accounting. Moreover, such commitments influence modal use to a greater extent than past behaviour (or habit). Studies generally find high stability in car-ownership. There seems to be a greater resistance or *status quo* effect to change car ownership than to reduce the level of car usage (Brindle 2003). This may have to do with loss aversion and a related concept, namely the endowment effect. In addition, Ellaway et al. (2003) found that car access provides psychological and social benefits, such as mastery, self-esteem, and feelings of autonomy, protection and prestige, which public transport users do not derive from their transport modes. These benefits are in turn associated with longevity and better health. Self-esteem depended on the type of car in the case of men but not women, while driving provided more benefits than being a passenger.

Car purchasing: Advertisement in mass media favours these positive associations affecting car purchasing. Bradsher (2002) notes that in the case of SUVs *versus* compact cars, marketing strategies have played a crucial role in making SUVs appealing to insecure, self-centred people, who want to appear frightening to others. Also regarding car purchasing, Larrick and Soll (2008) provide evidence that information on fuel efficiency framed as “miles per gallon” (MPG) can be misinterpreted. The reason is that people rely on linear reasoning (i.e., linearity heuristic) about MPG, which leads them to undervalue the benefits of small efficiency improvements on inefficient vehicles. In other words, people undervalue the benefits of replacing the most inefficient cars by new cars with higher MPGs and thus better performance in terms of fuel consumption (money savings) and carbon emissions (see also Schouten et al. 2014). A simple change, such as using “gallons per mile” (GPM) –fuel per distance– instead, would allow consumers to understand exactly how much fuel they are using and, with additional information, how much carbon they are emitting.

Cars, as well as houses, are both typical conspicuous goods that signal wealth (Hirsch 1976). Travellers show status seeking behaviour through the purchase of conspicuous goods and services as a way to signal reputation and social position. They further copy those relevant to them who seem successful. Car ownership, in fact, increases with income (Dargay 2001). Johansson-Stenman and Martinson (2006) found non-conscious concerns about self-image to be significant in car purchasing and related to the consumption of luxury cars signalling social position and wealth. They also found that subjects generally care about the environment, but not as much as they care for status. Interestingly, certain social subgroups derive reputation and status from showing environmental concern. In these cases owning a bike or a hybrid car may thus be a sign of status. Sexton and Sexton (2011) show that the willingness to pay for a Toyota Prius varies significantly with the environmental concerns of one’s neighbours, which is a sign of peer effect, conspicuous generosity or impure altruism (i.e., *warm glow*). Indeed, other hybrid car models were not as effective as the Prius in communicating environmental concern. The Prius was found to be superior as a symbol of environmental concern, possibly because it was the first commercially successful hybrid car and because it has a design that is easily distinguished from other cars (see Maynard 2007).

2.2.2 Short-term choices

Destination: Probably the first decision to study should be whether to travel at all. Travel is necessary for reaching destinations and to participate in daily activities. Some travelling may be difficult to avoid, like commuting, unlike other types like socially induced trips. Some socially induced trips (e.g., assisting someone going to a doctor or participating in joint activities) have been considered a form of altruistic behaviour which can be influenced by social norms and expectations that others will reciprocate (Goulias 2007; Goulias and Henson 2006).

Most short-term travel choices are repetitive and the result of daily routines, with fixed combinations of destination, departure time, route choice and travel mode. Indeed, travel-activity patterns are organised around a small number of fixed activities or stops (Hanson and Huff 1982, 1988). Repetitive trips to habitual destinations stimulate automatic travel responses.

Regarding the combination of choices “departure time” and “route selection”, auto-commuters surveyed in Taiwan leave home at the same time 82% of the time and take the same route as the previous day 90% of the time (Jou et al. 2008). Most commuters are not likely to change their departure times and routes, suggesting either that the commuters are very familiar with their commutes (i.e., show habit) or that the combination of departure time and route taken is already optimal or at least satisficing.

Departure time: Reference-dependency, loss aversion and diminishing sensitivity, can explain departure time adjustments among commuters (Jou and Kitamura 2002; Jou et al. 2008; Senbil and Kitamura 2004). Travellers may have several reference points (e.g., earliest permissible arrival time, preferred arrival time, and starting time of work) and therefore early arrivals (i.e., gains) can still be valued negatively, even though late arrivals (i.e., losses) would certainly be valued (more) negatively. Jou and Kitamura (2002) noticed diminishing sensitivity to time gains: for example, the subjective value of gains of 0 to 5 minutes is higher than that of gains of 20 to 25 minutes. Hjort and Fosgerau (2012) moreover demonstrated that this diminishing sensitivity effect is stronger for travel expenses than for time costs, for both car trips and public transport trips.

Route selection: The way information about travel time distributions is framed affects route choice. Travellers dislike uncertainty about travel time (i.e., travel time variability) more than they dislike long travel times (Bates et al. 2001; Noland and Polak 2002; Senna 1994). They are bad at computing probabilities, and so use simplification rules and are more inclined to reliable alternatives. In an experiment on route selection, Avineri and Prashker (2004) found evidence of certainty effect (i.e., underweighting of high probabilities) due to risk aversion, and risk-seeking behaviour for choice settings implying low-probability, high-reward outcomes. In addition, de Palma and Picard (2005) found that absolute risk aversion is constant and larger for public transport users than for car users with regard to both expected travel time and travel time variability.

Reference-dependency and judgement errors can further explain suboptimal choices between bus lines following different routes, as well as the “waiting time paradox”, according to which public transport users perceive that they always have to wait too long for the bus (Avineri 2004). For the case in which travellers are provided with information about headways, they may erroneously take the average waiting time (i.e., half the headway) as a reference and by setting such a low value as reference, additional waiting is usually framed as a loss. This misconception can in turn favour a particular form of preference reversal, namely the selection of a suboptimal bus route, only because the frequency of such bus line seems to be comparatively lower and have not much delay.

For particular choices, and under certain conditions, results from iterative tasks with immediate feedback, such as choices in transport contexts, are biased but go in the opposite direction of those predicted by Prospect Theory (i.e., one-shot tasks based on a full description of the choice problem); loss aversion is the only bias that appears robust in both iterative and one-shot tasks choice contexts (see Barron and Erev 2003). Under imperfect information travellers learn about travel time distributions from their experiences. Choices are repetitive and they get immediate feedback on actual travel time. However, their estimates about travel time distributions can be inaccurate in some cases (not leading to the best choices), for instance, if estimates are based on recent bad outcomes or small samples of outcomes, or if payoff distributions have large variances. The latter stimulates exploration (i.e., more random choices) and slows learning, thus, leading, on average, to more sub-optimal choices in the medium-term (see Erev and Barron 2005). Mahmassani and Srinivasan (2004) noted that subjects without reliable information overreacted to negative experiences, such as being stuck in traffic in the previous period, by switching more their departure times and routes in response. Recent events are more heavily weighted, while bad experiences are retained in memory for longer times (salience and vividness heuristics), which reduce the probability that a risky choice is repeated but impede learning about the actual value of the alternative –the so-called “hot stove” effect (Denrell and March 2001). Avineri and Prashker (2005) found evidence of this payoff variability effect. Moreover, they noted that in some cases increasing travel time variability of the route with the highest expected travel time could increase its perceived attractiveness, thus implying an underweighting of low probability outcomes and preference reversal.

Travel mode choice: (Mis)perceptions about reliability also affect travel mode choice, even when some information is provided as in the previous case regarding the “waiting time paradox”. Bates et al. (2001) acknowledges that with regard to subjective perceptions of travel time variability or the reliability of different travel modes, there are relevant differences between the car and public transport; notably, the car is perceived to be comparatively more reliable than public transport. As Bates et al. point out, in the case of public transport, the presence of a schedule involving potential waiting time or trip-duration favours establishing comparisons among the actual and the scheduled waiting/journey time, and so any discrepancy may be interpreted as unreliability and incurring time losses, even though a certain delay might be constant, which would imply no variability. Hence, for advertised public transport services, reliability and punctuality (i.e., adherence to schedule) are closely related. Indeed, misconceptions about travel time costs (and systematic underestimation of car-related expenses) can explain choosing the car over public transport (Bonsall et al. 2004; Gardner and Abraham 2007). Van Exel and Rietveld (2009a), in a study for Amsterdam, found that on average car travellers’ perceptions of public transport travel time exceeded objective values by 46%, and that if perceptions were more accurate, two out of three car travellers that currently do not see public transport as an alternative would include it in their choice-set, and use it from time to time. In addition, individuals with marked preferences for cars tend to use information on punctuality and actual travel times to reinforce car choice (i.e., confirmatory bias) and show travel mode persistence, namely undergo the “car effect” bias (Innocenti et al. 2013). Nevertheless, information on public transport schedules can indeed lead to more use of public transport. Rietveld (2003) argues that the problem is not so much to inform public transport users, but how to frame the information provided so that biases connected to reference-dependency (e.g., loss aversion) are minimised and public transport use is encouraged as a reliable means of transport. For example, as full reliability of schedule information cannot be

guaranteed, providing information about probability distributions of arrivals or of travel times may be useful.

Habits are also a key factor in travel mode choice and can be generalised across choice contexts (Aarts et al. 1998; Aarts and Dijksterhuis 2000; Gardner 2009). Travel mode habits lead to misperceptions about non-habitual modes (e.g., systematic underestimation of performance attributes like reliability and disregard of cost differences) (Anable and Gatersleben 2005). Strong travel mode habits moderate and even preclude the effect of deliberated intentions to change behaviour (Aarts and Dijksterhuis 2000a), that is, create problems of self-control. It seems that habits also moderate the effect of moral obligations to behave pro-environmentally (Klößner et al. 2003; Klößner and Matthies 2004). Indeed, Anable (2005) noticed that habitual car drivers do not feel any moral obligation to decrease their car use.

Travel mode alternatives include other than utilitarian attributes, namely symbolic-affective and social ones. Anable and Gatersleben (2005) found that while utilitarian attributes are more important in explaining modal choice in commuting, for personal trips both utilitarian and affective factors are equally important. Yet, Steg (2005) notes that what best captures car use by young male commuters are emotions evoked by driving (notably, freedom, independence, comfort and apparent control), perceived social pressure favouring car use, and status seeking. The car is used by these commuters as a way of self-representation and to show membership to (i.e., imitate) relevant reference social groups. These feelings give the car a comparative advantage over public transport (Steg 2003; Steg and Gifford 2005). Whereas positive feelings ascribed to the car predict its use, negative ones like guilt and disappointment predict intentions to use public transport (Abrahamse et al. 2009; Carrus et al. 2008). Friends and family (i.e., relevant others), and a supportive social context, play a key role in transmitting the negative effects of car use and the positive ones of public transport, its reliability, lack of stress and possibility of undertaking a productive commute (i.e., working while travelling), which increase preferences for public transport use (Haustein et al. 2009; Murray et al. 2010; Popuri et al. 2011).

3. Lessons for environmental-transport policy

Here we discuss implications of the insights reviewed in Section 2 for environmental-transport policy. In doing so we distinguish between policy lessons that are connected to bounded rationality and to social preferences. Table 3 provides an overview and summary.

[TABLE 3 AROUND HERE]

3.1 Bounded rationality

3.1.1. Travellers are emotional

Travellers associate car use with positive affective feelings. Marketing and mass media have a high responsibility in promoting affective aspects of vehicles and hence publicising them might be prohibited or discouraged through taxation (see Avineri and Goodwin 2010). A study on “dirty” advertisement, namely advertisement that encourages consumption of pollutive goods, derives optimal rules, not just for setting a tax on *dirty* advertising, but also a subsidy on *clean* advertisement, and an optimal pollution tax and information provision by the government (e.g., Gsottbauer and van den Bergh 2014). These findings can be applied to the case of advertising cars, and transportation means in general.

A different side of emotions is illustrated by observations that negative feelings of shame and guilt encourage public transport use (Bamberg et al. 2007; Carrus et al. 2008). The literature in environmental psychology notes that public transport use can be promoted through the activation of pro-environmental values (Gärling et al. 2003; Lindenberg and Steg 2007). Such values are ascribed to responsibility and awareness about environmental impacts, which trigger feelings of moral obligation or personal norms to behave pro-environmentally. Results from O'Connor (2002) show that people who can accurately identify the causes and risks of climate change are more prone to reduce emissions voluntarily and support strong policy initiatives. Education is thus crucial to have people with a high level of environmental concern and a positive attitude towards frugality (i.e., to form strong personal norms) (Fujii 2006; de Young 1996). Although the positive role of environmental education is recognised as relevant by many transport planners, these insights from psychology studies give extra weight to it, notably in terms how environmental awareness is translated into feelings of responsibility. In addition to this, social psychology studies noticed that personal norms result from internalising social norms that criticize car use. Indeed, environmental and social values are positively correlated with one another in cases where environmental and social objectives go in the same direction (de Groot and Steg 2008), for instance in social dilemmas about public goods. Several ways in which this can be accomplished are outlined in Section 3.2.1 about norms.

Last but not least, financial incentives affect moral obligations to behave pro-environmentally (i.e., personal norms) through so-called crowding out effects. This denotes that when altruistic actions are paid people can be deprived of the feeling of having done something good and thus can become less motivated intrinsically to behave in this way. Paying to compensate the effects of their behaviour can give them the feeling that they have a right to deviate from pro-environmental behaviour (Clark et al. 2003; Frey 1992; Frey and Oberholzer-Gee 1997), namely “the right to pollute” (see also Section 3.1.5 about framing). Heymen and Ariely (2004) found that in the absence of prices people’s choices and efforts are guided by social principles, which are not sensitive to compensation, in contrast to monetary exchange in formal markets. Hence, when environmental norms are high, social incentives can be used instead of monetary. Of course, when pro-environmental behaviour is insufficient to solve the associated problem and financial incentives can do the job even if they cause some crowding out, then one has a good reason to go for such incentives. In other words, it is wise to consider the net effect rather than principally refrain from policies that cause crowding-out.

3.1.2. Travellers stick to the status quo and choose the default option

Travellers show a tendency to stick to the *status quo*. Such inertia can tip the balance towards polluting alternatives when presented as the mainstream or default option (e.g., gasoline and diesel cars, single housing and dwellings blocks with parking). A straightforward way to take advantage of default bias is presenting “green” alternatives as defaults. Examples of green defaults in the context of transport are electric and hybrid cars, and compact housing without parking. Appropriately setting defaults could further encourage certain departure times and routes to alleviate congestion. One way to do this is to designate environmental zones with limits on high-pollutant vehicles. Their entrance to these zones could be either prohibited or subject to taxation, which would send a clear message on what is to be favoured. Thaler and Sunstein (2008) argue that the effect of defaults could be reinforced if they are supported by norms and framed as the recommended action to take.

In addition, opt-out defaults, i.e., when the passive response means sticking to the default, increase the probability that the (green) default option is chosen (Johnson and Goldstein 2003). This would actually mean increasing electric and hybrid market shares and perhaps force

retailers to only publicise and showroom these car models. At the same time, limits are needed on the proliferation of low-density building. Two ways to avoid this are direct prohibition or increasing the costs to promoters for their construction. Overall, policies need to be more stringent when polluting default effects in the market are strong (Carlsson and Johansson-Stenman 2012). Notwithstanding this, Löfgren et al. (2009) found that when individuals are familiar with green alternatives, and as long the cost of switching is low, they may actively take the environmental option. This result is encouraging as it means that a green option can spread in an environmentally educated population without further persuasion, even though defaults may be necessary to encourage early adoption.

3.1.3. Travellers have separate mental accounts

Travellers use different mental accounts for fixed and variable time costs and money expenses derived from transport. Studies suggest that to decrease car use, it may be more effective to increase variable expenses of driving than fixed ones (Dargay 2008). Thus, raising fuel prices and setting emission taxes per kilometre driven or road pricing schemes may be good policy alternatives to discourage car use. Travellers even differentiate between travel modes. One consequence of this is that the costs and expenses of driving are generally underestimated relative to those of using public transport, which creates a competitive disadvantage for alternatives to the car. Mental accounts influence product choice, in that accounts and budgets are used as self-control devices to avoid overconsumption, which is a positive trait, maintaining driving levels low once variable costs of driving have increased (e.g., through policy). However, Cheema and Soman (2006) found that for ambiguous expenses, this self-control mechanism may fail because these can be assigned to more than one account which often justifies spending. Thus, from a policy perspective it may be a better strategy to simply raise current fuel taxes, tolls, etc. rather than introducing new pricing schemes that might be ambiguous to travellers without previous experience with such schemes.

3.1.4. Self-selection bias

Travellers select residential locations favourable to their travel mode preferences. Self-selection related to car lovers may be a problem here. Hence, it may be important to design mechanisms that simultaneously discourage car use and encourage sustainable location choices. Næss (2009), however, argues that self-selection bias highlights the importance of location choices; that is, there is a remaining effect on modal choice of the location of a residence and the neighbourhood typology (i.e., favourable or not favourable to car use) after controlling for self-selection bias. These findings support our previous suggestion on limiting low-density building (Section 3.1.2 about defaults) and emphasize the relevance of land planning policies that design neighbourhoods with attributes that discourage positive attitudes of households to the car, and thus car ownership and use.

3.1.5. Heuristics and information

Travellers use heuristics when interpreting descriptive information, which can lead to errors of judgement. However, adjusting information to travellers' reasoning can raise the effectiveness of information. In this vein, measures of fuel efficiency need to be expressed in "gallons per mile" (GPM) –fuel per distance– so that information is framed consistently with people's linear reasoning. Regarding information about expected travel time and the various measures of variability/reliability, it is unclear how people perceive mean-variance concepts and other characteristics of travel time distributions; most people are not even familiar with the concept of variance (or standard deviation) (Bates et al. 2001; Noland and Polak 2002). Indeed, reference

points are easily influenced by framing, yet are not completely understood by researchers, who think that may be endogenously set (see van Wee 2010). A realistic recommendation to cope with the “waiting time paradox” would be to set countdown markers. When it comes to the “car effect”, namely unreasonably disregarding alternatives to the car, there is much to be done in improving the image of public transport in terms of its reliability. Under incident conditions altering the normal functioning of public transport services, information plays a crucial role in avoiding the “hot stove” effect (Chorus et al. 2006). Take the example of public transport strikes. These can have a negative and lasting effect on the number passengers using the service (i.e., ridership), which can be minimised if travellers are well and timely informed, reducing the impact on the perceived reliability of the service while also giving them the opportunity to arrange alternatives (van Exel and Rietveld 2001; 2009b). The lesson is that (better framed) information will decrease uncertainty and ease decision-making, so that travellers will make more optimal choices (i.e., choose the alternative yielding the highest payoff, whether minimising travel time, travel costs, or environmental impact). However, still there are barriers to information. Travellers with strong habits, for instance, disregard travel information. Recommendations on how to deal with habits are put forward in Section 3.1.7.

Likewise, the effect of information about car alternatives in triggering change is limited due to both drivers’ preferences for reputation and status, and the “car effect”, which leads to biased choices. Satisfied car users are unlikely to seek information regarding alternatives that they perceive to perform poorly. Indeed, information about modal alternatives to the car will only have an effect provided alternatives clearly outperform the car in terms of travel times, expenses (i.e., costs) and image, and costs of information acquiring and eventual adaptation (i.e., changing the choice with all its consequences) (Chorus et al. 2006). More stringent policy forcing modal change is thus necessary in these cases (see Section 3.2.2 about status).

3.1.6. Feedback affects learning by travellers

There is a further role information can take. Many studies indicate that feedback is a necessary element in learning for travellers. Travellers already receive immediate feedback on actual travel times and trip expenses, especially in the case of public transport where they have to pay for a ticket, and to a lesser extent in the case of cars (because of fixed costs). However, the effect of information in travel contexts where travellers also learn through experience is limited. Several studies have investigated this issue for the case of travel time minimisation through route choice (Avineri and Prashker 2006; Ben-Elia et al. 2008; Selten et al. 2007). It seems that, initially, information about travel time distributions has positive effects —increases initial risk seeking behaviour, reduces initial exploration and increases between-subject differences—, but as travellers become more experienced, behaviour moves towards the predictions of the payoff variability effect (Ben-Elia et al. 2008). Inexperienced travellers thus benefit more from information than experienced ones (see also Section 3.1.7 about habits). These results are further confirmed for travel mode choices, even in the more realistic case when information is costly (Denant-Boèmont and Petiot 2003). Travellers, however, do not get immediate feedback from their choices in terms of actual CO₂ emissions, which they do get in terms of actual travel times, etc. Learning is thus complicated, and external feedback/information is necessary. Coulter et al. (2008) investigated the role of carbon calculators in shaping people’s understanding, attitudes and behaviours; participants could experiment with a range of carbon calculators, though. They noticed that most people have a limited understanding of emissions-related concepts and cannot well connect emissions with their own behaviour. Particularly, for the case of travel behaviour, a high resistance to change is associated with perceptions about limited alternatives, reliability, time and costs being more important than environmental

concerns, as well as with blaming others for the increase in emissions. Emissions meters could alternatively be adapted for their installation into cars. In this vein, Ericsson et al. (2006) show the possibility of including information on fuel-efficient routes in innovative navigational systems, which would reduce CO₂ emissions of car journeys. Although there is still scope for improvement –further research with vehicle navigation companies is necessary– results from a pilot case in Lund (Sweden) show that route optimization to the lowest total fuel consumption (and the lowest emissions) can result, on average, in 8.2% reduction in fuel consumption. The potential for improvement is thus significant; in Lund 46% of all journeys over 5 minutes are not adjusted to the most fuel-efficient route.

3.1.7. Loss aversion and negative framing

Travellers dislike losses. Choice outcomes can be framed as losses to persuade travellers towards a desired choice. Avineri and Prashker (2004) showed how negatively framed information about travel time distributions could trigger route changes towards reliable routes. However, learning can reduce loss aversion in view of uncertainty about travel time costs (Avineri and Prashker 2005; Ben-Elia et al. 2008). Avineri and Waygood (2013) found that negative framing is actually more effective than positive framing in highlighting differences between travel modes in terms of associated CO₂ emissions. They compared sets of modes including bicycle, full car, and single occupancy of a SUV vehicle, and framed information on emissions as “lower” or “higher” to signal whether a travel mode was “better” or “worse”, respectively. Negative framing has, though, side-effects effects, notably on how pricing mechanisms are understood. Nash (2006) investigates these effects on consumers, voters, business community, and environmental NGOs, and finds that pricing mechanisms can be understood as giving the “right to pollute”. This perception can lower their effectiveness. Accordingly, pricing mechanisms could be better framed as “penalties” to avoid such misinterpretation. In addition, this frame of “right to pollute” explains differences in opposition between pricing and regulation, with the latter being more opposed as it is perceived to restrict freedom of choice. This insight has implications on how to present some policies to both travellers and politicians to seek maximum acceptability, especially if policies are necessary.

3.1.8. Travellers are creatures of habit

Strong travel habits pose obstacles to behaviour change. Gärling and Axhausen (2003) argue that habits need to “unfreeze” to allow conscious deliberation of behaviour if change is to occur. Both Garvill et al. (2003) and Eriksson et al. (2008) notice positive results of so-called “deliberation intervention”, where participants are induced to deliberate about alternatives to their habitual choices. The intervention was particularly successful for car users with a strong car habit and a strong moral motivation (or personal norm) to reduce personal car use. Deliberation can also be prompted through changes in the choice context. Verplanken et al. (2008) found for modal choices that residential relocations allow conscious renegotiation of past habits, activating pro-environmental intrinsic values that guide behaviour toward sustainable alternatives. Habits can also be broken and formed through financial incentives, with long-lasting effects (Charness and Gneezy 2008; Fujii and Kitamura 2003). Bamberg (2006) tested the synergic effects of these insights through an intervention carried out after residential relocation. This involved providing a 1-day free ticket and personally tailored information about public transport services. The intervention caused an increase in public transport use from 18% to 47%. Car use habits significantly decreased after relocation and behavioural changes took place for both habituals and non-habituals. Moreover, participants significantly changed their attitudes and beliefs about the feasibility and adequacy of using public transport. In this case, no

crowding-out effects were described (see also Hunecke et al. 2001). Alternatively, interventions such as temporary road closures (Fujii et al. 2001) and the withdrawal of parking spaces (Brown et al. 2003), necessarily force a change of travel mode. These measures are more in line with insights from behavioural economics in that the habitual response is interrupted. Behaviour change was effectively achieved in these two cases. As in the case of incentives, public transport usage was maintained because the tryout experience resulted satisfactory while the negative perceptions held about public transport were shifted. Finally, some studies suggest that when habits create a negative environmental externality, the environmental tax must be increased beyond the traditionally optimal (Pigouvian) level to make change possible (Fuhrer 2000; Leith et al. 2012; Löfgren and Nordblom 2006).

3.2 Social preferences and self-identity concerns

3.2.1. Travellers take norms as mandates and follow relevant others

Most pro-environmental behaviours can be explained by peoples' motivation to behave appropriately and fit within their social contexts (Dawney and Shah 2005; Lindenberg and Steg 2007). Studies from social psychology reveal that we learn how to behave and what is appropriate by observing and copying the behaviour of others, so-called "social proof". In this vein, schemes such as congestion charging in central London reduce "social proof" of car use acceptability, while highlighting the desirability of using sustainable alternatives for environmental reasons. These price-based mechanisms are however quite contested, and hence difficult to implement; people are insecure about how these interventions affect their daily life in terms of personal losses (less car use and higher financial costs). Yet, findings from Schuitema et al. (2010) show that experiencing the benefits of congestion charging during trial periods increases their acceptability.

Norms can also play a relevant role in increasing the effectiveness of information provision. Cialdini (2003, 2007) suggests using messages with injunctive norms (perceptions about socially approved behaviours) when the intention is to change an environmentally undesirable but socially extended behaviour; and using descriptive norms (perceptions about behaviours socially extended) to reinforce a pro-environmental behaviour that is sufficiently extended. These types of normative messages can indeed be publicised in traffic panels to discourage driving, just the same way as information on congestion and accidentability is publicised.

The effect of norms on social dilemmas has been extensively researched. Quitting the car has frequently been regarded as a social dilemma; while driving a car (i.e., to free-ride) may be in the individual interest, less driving (i.e., to cooperate) is in our collective interest and makes all better off (Vlek 2000). Biel and Thøgersen (2007) review the application of norms in iterative dilemmas, such as travel decisions. They argue that what others do is likely to influence individual behaviour based on expectations about reciprocity and conditional cooperation. In this sense, Gaker et al. (2010) found, through an experiment, that information of peer compliance with pedestrian laws has a stronger influence on pedestrian safety behaviour than descriptive information (e.g., accident statistics or citation rates). Still some people may feel that their contribution is irrelevant compared to that of others (Lorenzoni et al. 2007).

To free-ride is considered a violation of the equity norm. Violations of social norms in dilemmas are often responded to by sanctions. Social punishment and rewards encourage cooperation. Public disclosure is a form of social punishment that includes reputation concerns. Examples applicable to transport include publicising car or individuals' emissions and energy use, placing signals in pollutive cars, and labelling (Rand and Nowak 2009). Yet, while

publicising personal information can be complicated due to privacy policy, implementing a labelling scheme for cars is something realizable.

3.2.2. Travellers seek status and care about self-image

A travel mode such as the car is valued in both utilitarian (time and money costs) and social terms (reputation and status). The presence of status-seeking behaviour means that the level of optimal correcting taxes for conspicuous goods that damage the environment needs to be raised (Howarth 1996). However, under status seeking prices may sometimes send the wrong message and so it may be more efficient to deal with status through income taxes (Aronsson and Johansson-Stenman 2008; Ireland 1998). An alternative for the context of transport is proposed by Verhoef and van Wee (2000), namely feebates on new cars dependent on emissions/fuel consumption. That is, the amount of the feebate is determined by the relative fuel efficiency of a vehicle; the fee is applied to more polluting cars, whereas less polluting cars receive the financial incentive (i.e., the rebate). An elaborate discussion of the effects of feebate schemes and design options is offered by de Haan et al. (2009), Mueller and de Haan (2009), and Peters et al. (2008). Status, however, does not depend only on material wealth but on social reputation. We have already discussed that some social groups derive utility from showing environmental concern. Linking these social preferences, namely status seeking and reputation, could alter behaviour in an environmentally favourable direction. Griskevicius et al. (2010) actually demonstrated that eliciting status motives can be an effective way to promote pro-environmental behavior. Status motives increased desire for green products (including hybrid or electric cars) when shopping in public (but not private) and when green products cost more (but not less) than non-green products, so that green products can simultaneously signal one's "caring" and "wealth". The experiment assessed different products and their green counterparts, including cars (traditional *versus* hybrid models). Environmental studies further point to "conspicuous generosity", namely the desire to appear generous in front of others, as a way to get people to cooperate in social dilemmas (Andreoni 1989; Andreoni and Petrie 2004; Alpizar et al. 2008).

4. Conclusions

Much of transport reality is better described by behavioural approaches than by rational agent models. Behavioural economics offers alternative and comprehensive answers to the questions of why people behave as they do and why it is difficult to change travel behaviour. The literature gives evidence for the following stylized facts about bounded rationality, namely travellers are: (1) emotional, (2) stick to their *status quo* and choose the default option, (3) separate accounts to process costs of action, (4) self-select environments favourable to their preferences, (5) use heuristics, make errors and misinterpret information, (6) learn about their travel context, (7) are influenced by negative frames, and (8) are creatures of habit. Concerning social preferences, travellers (9) take norms as mandates and care about reputation, and (10) seek status and follow relevant others. In addition, some reinforcing effects among biases are worth mentioning, notably the amplified effect of "reliability bias" and the "car effect", and the effect of social norms on status and affect heuristics favouring car usage.

These characteristics of travellers produce systematic biases in their behaviour that interfere at all stages of decision-making. Behavioural anomalies can be described either for long-term choices affecting day-to-day travel choices (residential and employment locations, owning a driving license and car purchasing), or short-term daily travel choices (destination or activity choice, departure time, route and travel mode choice). Behavioural deviations are a source of ineffectiveness in traditional environmental policy and so the recognition of them in

policy design is highly recommendable. It even allows for testing types of instruments other than traditional ones, such as a tax on “dirty” advertisement, different defaults, newly framed messages, deliberation interventions, and social incentives and disincentives (public disclosure).

Policies to address bounded rationality involve penalising the promotion of positive feelings ascribed to driving, while encouraging negative ones of guilt and shame. Supportive norms and environmental education motivate people to behave pro-environmentally. In addition, green alternatives can be presented as the recommended default option; e.g., provide “social proof” of hybrids and electric vehicles. Regarding social preferences and self-identity concerns, social pressure favouring green alternatives and behaviours can be very effective; people mostly want to fit within their social contexts and appear generous. Defectors can be punished through public disclosure (e.g., car labelling). Peers and neighbours have a great influence on individuals’ behaviour. Thus, green behaviours and attitudes of peers and neighbours can be published to provide a positive reinforcement and ease behavioural change. Finally, reputation and status concerns could work together through the promotion of social status over material wealth to favour sustainable alternatives. Marketing strategies could improve the social image of green alternatives and make them fashionable; the “Prius effect” can be taken as a successful example. Reinforcing effects can be obtained if role models became involved and people copied them.

Traditional policy instruments need to be adapted whenever systematic biases affect the effectiveness of measures. The effects of information in triggering behaviour change are limited when alternatives to the car do not outperform at utilitarian (time and money costs) and social levels (e.g., provide reputation and status). Providing accurate and reliable information during incidents is cost-effective and corrects misperceptions that can lower public transport use; public transport users show relatively higher degrees of risk aversion due to time losses than car users. Adapting information to travellers’ heuristics can aid decision-making, while normative messages can increase the effectiveness of information provision by providing “social proof”. Furthermore, polluting alternatives can be discouraged through negative frames that focus on their poor environmental performance. Framing can further affect the support for price-based mechanisms, which need to be presented as environmental penalties. For pricing mechanism entailing major opposition, such as road pricing schemes, trials can help increase their acceptability. Financial incentives can crowd-out intrinsic motivations to behave pro-environmentally but they seem to have a positive effect in the formation of sustainable habits. Travel mode habits can break when context changes are forced. The presence of norms, habits and status seeking behaviour favouring polluting travel behaviour affect the size of any optimal corrective tax. In the case of status seeking, prices could send the wrong message anyway. In this case, correction could be considered through income taxation and feebates.

All in all, policy strategies need to be perceived as fair and just. Policies need to involve all actors (travellers, car producers, the automotive lobby, public authorities and the media sector) so that travellers feel that everyone is contributing and thus reciprocate. This paper has shown that insights from behavioural economics can play an important role in understanding how effects on travellers of heuristics, information filtering, norms and status can be effectively addressed through transport policy.

Finally, a few comments are in order regarding potential future research. Little is known about how people perceive mean-variance concepts and other characteristics of travel time distributions, even though these are likely to affect their perceptions of reliability and time costs of public transport. Experiments can be designed to systematically explore the effectiveness of different frames to inform travellers about expected travel times and the frequency of the service (e.g., countdown, information about probability distributions of arrivals

or of travel times). This is of crucial importance as reinforcing effects amongst “reliability bias” and the “car effect” have been observed. Notably, the car is constantly and invariably perceived to be comparably more reliable than any public transport alternative (metro or bus). Providing information about the service of public transport is necessary to improve its image in terms of reliability. Yet, how such information is framed is crucial inasmuch information about punctual delays can be filtered and used to further justify car choice. At the same time, the car is also favoured because of its connection to people’s reputation and self-esteem. This connection does not exist for public transport, which creates a comparative disadvantage with the car in social and affective terms that adds up to that of perceived reliability. Ways in which this can be addressed have been highlighted, yet more effective interventions could be tested. Last but not least, research could identify additional heuristics that have not been detected yet. Thereby, further research in this line is also encouraged.

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Table 1. Summary of concepts and insights from behavioural economics.

Bounded rationality and Prospect Theory	JUDGEMENT ERRORS: imperfect information, complexity and individuals' limited computational abilities; use of heuristics and judgement biases	Affect heuristic	Choices are based on feelings and emotions, as well as on one's mood.
		Anchoring and adjustment	People make an initial guessing of probabilities, based on substandard cues, and stick close to their initial guess. They ignore additional information that contradicts their initial hypothesis.
		Lexicographic preferences ("car effect" bias and "self-selection")	Simplification of a decision choice set by focusing on only one (or few) attribute(s). A particular type of lexicographic preference affecting travel mode choice is the so-called "car effect" bias, which denotes individuals showing a marked preference for the car, even when this alternative is risky and does not necessarily involve the minimisation of total costs. In this situation, car choice is favoured by prioritising affective factors instead of economic ("rational") ones. <i>Self-selection</i> regarding residence location and travel mode choices means that people choose a house location prioritising their anticipated travel mode decisions –whether walking, cycling, public transport or driving a car.
		Linearity heuristic	<i>Linearity heuristic</i> consists in erroneously assuming a linear relation between two variables/measures. Larrick and Soll (2008) describe it and provide evidence of this "linear reasoning" by travellers when assessing vehicle fuel efficiency as measured in "miles per gallon" (MPG). As a consequence, people undervalue the benefits of small efficiency improvements on inefficient vehicles. "Gallons per mile" (GPM), on the other hand, implies a linear relation between miles driven and fuel consumption, which allows for intuitive calculations and vehicle comparisons.
		Average (waiting time) heuristic	When travellers are provided with information about headways, they can erroneously take the <i>average waiting time</i> (i.e., half the headway) as a reference. However, this would only hold if the bus was a fully reliable mode and variance was zero. Users often have to wait longer than the average waiting time. By setting such a low value as reference (half the headway), additional waiting can give the feeling of having to wait too long for the bus, hence the "waiting time paradox".
		Default bias	People choose the default option in a complex choice set, thus disregarding other alternatives' attributes or choice outcomes.
		Confirmatory bias (illusory correlation, hindsight bias, "filtering")	People use information to justify their initial guesses and choices. They may "filter" information to such an end (<i>filtering effect</i>). In a similar way, people may assess past choices on the basis of new information they did not had when choices were made (<i>hindsight bias</i>).
		Mental accounting	People keep mental accounts for different expenses. This violates the fungibility property of money.
		Salience and vividness heuristics, "hot stove" effect	Individuals weight extraordinary evidence disproportionately against the odds, even when information about actual probabilities is available. Recent events are more heavily weighted (i.e., more <i>salient</i>), while negative experiences are retained in memory for a longer time (i.e., more <i>vivid</i>). The availability of this information, which can be readily retrieved from memory, reduces the probability that a risky choice is repeated but impedes learning about the actual value of the alternative –the " <i>hot stove</i> " effect.
	CHOICE UNDER RISK AND UNCERTAINTY: context-dependent preferences, alternatives framed as either gains or losses, and probabilities weighted non-linearly	Framing	The way a set of options in a decision problem is formulated (i.e. "framed") influences individuals' preferences.
		Loss aversion	Individuals have asymmetric preferences for gains and losses. People put a higher value on losses than on same-sized gains, and dislike to take (even) small risks. In addition, people are <i>risk averse</i> over gains and <i>risk seeking</i> over losses.
		Endowment effect	Individuals are <i>loss averse</i> and value more the things they own than those not. This effect can be immediate and arbitrary (i.e. recently owned things), though the longer the tenure, the higher the value assigned.
		<i>Status quo</i> effect ("choice persistence" or "inertia")	People stick to their original choices (i.e. <i>status quo</i>), even if change would cause substantial improvement, thus showing <i>choice persistence</i> or <i>inertia</i> . This is a consequence of losses being disproportionately valued and the <i>endowment effect</i> .
		Certainty effect ("reliability bias")	People prefer certain (reliable) over uncertain or probabilistic outcomes (Tversky and Kahneman 1981). As a consequence, choice outcomes that are framed as sure losses lead to <i>risk seeking</i> behaviour (overestimation of low probability outcomes or rare events), while choice outcomes framed as sure gains lead to <i>risk averse</i> behaviour (underestimation of high probability outcomes).
		Preference reversal	Individuals with stable, well-defined preferences can end up choosing an option that is not the one they value the most. Preference

			reversal can be induced by a change of the reference point or by the introduction of a decoy option into a set of options. The latter will tip the balance towards the non-decoy option, not chosen otherwise.
	TIME-INCONSISTENT PREFERENCES AND SELF-CONTROL PROBLEMS: inter-temporal choice and habit formation	Hyperbolic discounting, immediacy effect	People value present rewards much highly than future gains. As a result, individuals sometimes make decisions which are not in their best long-run interest (i.e. myopic behaviour). This deviation partly explains <i>procrastination</i> , addictions and habitual behaviour.
		(Lack of) self-control	The “need” over the “will” or lack of self-control is explained by people valuing present gains much more than the future ones.
		Habits	Habits are automatic, non-deliberated responses formed through the repetition of a satisfactory course of action that is stored in memory. Habitual behaviour can be explained by having time-inconsistent preferences, but habits can also (positively) be seen as mental shortcuts or simplification heuristics that save costs of search, information processing and deliberating a decision.
	Social preferences and self-identity concerns	SOCIAL PREFERENCES AND SELF-IDENTITY CONCERNS: limited self-interest and self-identity concerns	Fairness, equity, justice
Altruism, “warm glow”, reciprocal altruism			People value the well-being of others. A distinction is made between “pure” <i>altruism</i> (i.e. when an action is taken on a generous way and without receiving anything in return) and “impure” <i>altruism</i> (i.e. when the action produces some sort of benefit to the altruistic individual; <i>warm glow</i> and <i>reputational altruism</i>). Altruism can further take the form of (<i>direct or indirect</i>) <i>reciprocal altruism</i> , namely individuals expect to be treated well by a person they have treated well.
Norms			People usually care about others’ behaviour and seek to behave appropriately. Social and personal behaviour are guided by norms and rules, which are (often) developed socially. Social norms are injunctive (i.e. describing a socially accepted behaviour) or descriptive (i.e. a norm that describes an extended behaviour) (Cialdini 2003, 2007).
Status, relative income, positional goods, conspicuous consumption			Status denotes a social position often signalled by more wealth relative to others. The consumption of <i>positional goods</i> which show one’s relative wealth (i.e. <i>conspicuous consumption</i>) is one way in which individuals derive status. Individuals further derive reputation from showing membership to high status, relevant reference groups.
Role models and peer effects			Role models are “salient” members of relevant reference social groups (i.e. well positioned socially), which may influence the behaviour of those individuals who value being becoming a member of such social group. In this vein, the behaviour of friends, family and peers (i.e., relevant others) can also influence one’s behaviour, since they can be taken as role models for desirable behaviour.

Note: Classification of behavioural economic insights inspired by Gsottbauer and van den Bergh (2011). Unless indicated otherwise, insights on behavioural biases were retrieved from Ariely (2009), Camerer (1999), Kahneman (2011), McFadden (1999), Rabin (1998), and Shogren and Taylor (2008).

Table 2. Set of travel choices that individuals and households face.

Set of travel choices	
<i>Long-term choices</i>	<i>Short-term choices</i>
• Residential and employment location • Car license • Car ownership and car purchasing	• Destination • Departure time • Route • Travel mode

Table 3. Environmental-transport policy analyses for the set of long-term and short-term travel choices.

	Travellers' biases	Evidence from behavioural economics studies	Implications for environmental-transport policy
Bounded rationality, Prospect Theory and Time-inconsistent preferences	• Are emotional	Value both utilitarian and affective attributes of jobs, houses and travel modes (vehicles).	Positive emotions ascribed to the car favour car use and habit formation, and should be discouraged. Public transport use may be triggered through feelings of guilt and shame associated with car use, which, in turn, can be promoted by educating people to take responsibility for one's impact. Travellers with strong pro-environmental motivations are more prone to adopt (new) sustainable alternatives.
	• Stick to the <i>status quo</i> and choose the default option	Stick to current choices, particularly if they are socially accepted.	Green alternatives (e.g., electric and hybrid cars and compact housing without parking) can be presented as defaults. Opt-out defaults increase the probability that the green option is chosen. Defaults are more effective when travellers are unfamiliar with green alternatives.
	• Have separate mental accounts	Use separate accounts for fixed and variable costs of driving.	Increasing variable costs of driving has a greater effect than increasing fixed costs. The introduction of new pricing schemes can reduce the effect of mental accounts in controlling consumption.
	• Self-selection bias	Self-selection bias affecting location choices in favour of (private) travel modes.	Instruments can be designed that simultaneously discourage car use, while encouraging sustainable location choices. Land planning policies focusing on sustainability.
	• Use heuristics and misinterpret information	Use of simplification heuristics (e.g., linearity heuristic, average waiting time heuristic, lexicographic preference for the car or "car effect", salience and vividness) and make errors regarding travel time and money costs that suggest a systematic bias towards the car, disregard information that does not match one's preference (filtering) or disregard information at all in the case of strong habits and status seeking.	Some descriptive information can be framed to account for travellers' particular reasoning, something that would increase the likelihood of changes. Removing barriers to information, and finding ways of presenting information that seems complex at first (e.g. information about probability distributions, energy efficiency and other emission-related concepts). Information plays a crucial role during incident conditions (e.g., strikes, accidents, break-downs), avoiding the "hot stove" effect. Information has its limits – due to habits and status – and so more stringent policy forcing modal change is necessary in these cases.
	• Learn about their travel context	Learning does not guarantee more optimal choices in the medium-term.	Feedback is a necessary learning tool and helps redressing misperceptions. Overall, descriptive information about travel time distributions has positive effects, though inexperienced travellers benefit more from information than experienced ones. There is potential for external provision of feedback/information about environmental performance (i.e., CO ₂ emissions).
	• Loss aversion and negative framing	Take previous status as a reference, value asymmetrically gains and losses relative to it, and respond to framed information showing loss aversion.	Choice outcomes can be framed as either gains or losses to persuade travellers towards a desired choice. Negative frames have a relatively greater influence on behaviour (retained for longer times). Experience can diminish the effects of loss aversion. Pricing mechanisms can be understood as giving "the right to pollute" instead of signalling that "the polluter pays", and regulations can be understood as taking away freedom of choice.
preference s and self- identity	• Are creatures of habit	Act moved by habits, which moderate the effects of norms and deliberated intentions to change behaviour, and lead to misperceptions about the performance of non-habitual travel modes.	Unsustainable habits can be "unfrozen" through interventions that induce conscious deliberation of current choices and alternatives. Habits break when there are life-changing events (job and residential relocations); travellers are more receptive to information during these moments. Sustainable travel habits can be encouraged through economic incentives. Other changes in the choice context, such as temporary road closures and the withdrawal of parking spaces, force a change of travel mode and are highly effective. If habits create an undesired consumption externality optimal Pigouvian taxation needs to be adjusted.
	• Take norms as mandates and follow relevant others	Are motivated to behave appropriately and fit within their social contexts, and care about what nearby people do and think.	Norms can encourage both pro-self and pro-environmental behaviours depending on the social context, and so it is necessary to create a social environment that favours sustainable travel alternatives. The effectiveness of information can be raised by capturing travellers' normative concerns; and injunctive and descriptive norms promote cooperation in social dilemmas. Pro-social and pro-environmental behaviours are positively correlated in cases where objectives line up.

			Social rewards and punishment (e.g. public disclosure) help raising contributions and induce voluntary changes. If norms create an undesired consumption externality, optimal Pigouvian taxation needs to be adjusted.
	• Seek status and care about self-image	Want to show their wealth and appear generous in front of others.	Reputation and status concerns can favour car use over public transport; feebates can be used to correct for the effects of status. Status-seeking behaviour creates a consumption externality and optimal Pigouvian taxation needs to be adjusted. Status seeking can be used to promote pro-environmental behaviour, particularly when green products cost more than their non-green counterparts. Status seeking behaviour and self-image concerns can lead to conspicuous generosity or impure altruism (<i>warm glow</i>).

Figure

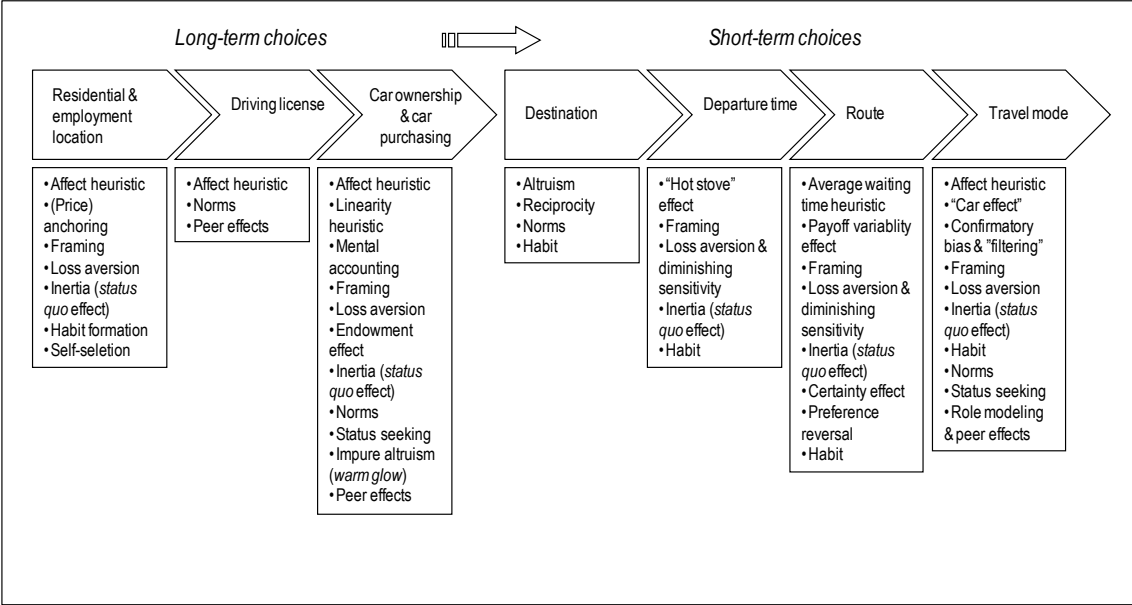


Figure 1. Behavioural biases and anomalies in short- and long-term travel choices.

Highlights

- Travellers' choices in transport are often better described by behavioural approaches.
- We present a brief overview of main insights of behavioural economics.
- We review empirical evidence on travellers' biased choices.
- We distinguish between long- and short-term travel choices.
- Lessons for design of environmental-transport policy are derived.

Responses to the Editor and to Reviewer #2

Ms. Ref. No.: TRD-D-14-00110

Title: Behavioural economics, travel behaviour and environmental-transport policy

Journal: *Transportation Research Part D: Transport and Environment*

(Note: Our response is in italics)

Response to the EDITOR:

Reviewers have now commented on your paper. You will see that they are advising that you revise your manuscript. If you are prepared to undertake the work required, I would be pleased to reconsider my decision.

Thank you for giving us the opportunity to revise and submit. We have addressed all the comments and suggestions. In addition, a professional copyeditor has proofread the text. Below are detailed responses to the reviewer.

Response to Reviewer #2:

The paper reflects on behavioural aspects in travelling choices that are insufficiently recognized in standard environmental transport policy, seeks to give a literature review and structure policy implications.

The topic is crucial - it explains why much of transport policy has not been as effective as had been hoped for, and the means and directions it could be improved.

The structure of the paper in principle is well chosen to achieve the above objectives. Research topics and authors from environmental psychology are well represented in the manuscript.

Thank you for this positive evaluation.

There are, however, some aspects, where the paper could (and should) be improved:

(1) Relevance of references: While the paper is quite specific in references given in sections 2 and 3, the motivating parts in section 1 do mention references, but are not as representative there as they could be. E.g. the argument "there is an ever growing number of studies that" (first paragraph of section 1) is motivated by 3 climate policy studies (2 of which focus on specific countries only), and just one "behavioural study". I think the argument could be motivated further by respective references, especially surveys.

Relevant references to surveys on behavioural studies have been added.

(2) Knowledge is presupposed, where information should be given.

This refers mainly to section 2. E.g. in its third paragraph some project (?) names are given, such as "NUDGE", "MINDSPACE", or a "NEF" report is referred to, which an international reader cannot relate to, and would need to be introduced with content information rather than project acronyms. (e.g. what are the "seven principles of the NEF report?")

These issues are now briefly explained.

This also refers to section 3, where, for example, the end of section 3.2.1 mentions "so-called crowding out effects" without explaining what is crowding out what.

This is now explained.

(3) The inherent structure is not fully consistent

In section 3, most of the subsections end with specific policy implications - but not all do. E.g. in section 3.1.7 no such policy conclusions are given.

Please carefully reconsider the information given and structuring, and complement all subsections, where the reader cannot take specific conclusions yet.

A concrete suggestion to cope with the effect of salience and vividness (in Section 3.1.7) and a derived effect, namely the "hot stove" effect, is now made based on the results from studies on rail strikes affecting ridership. Section 3 has been modified to take into account the suggestions made below to provide more concrete policy recommendations. In addition, when examples of how a particular policy can be implemented are available and relevant for the context of transport, we provide them. Particularly, we have noticed that having as much as four separate sections on information and judgement biases was misleading and led to this situation of sometimes not deriving concrete policy implications. Therefore, some of these sections on information (including Section 3.1.7) have been eliminated, while relevant insights have been combined into Sections 3.1.5 and 3.1.6, and policy implications have now been clarified.

(4) While the structure of section 3 is well adjusted to that of the relevant Table 3, and the reader thus can easily follow, the same is not true for section 2 (and its link to relevant tables 1 and 2, which is quite hard to establish for the reader).

This has been corrected. The text in Sections 2.2.1 and 2.2.2 now follows an order consistent with the travel choices in Table 2. Furthermore, the contents of Table 1 have been adjusted to match the structure of Sections 2.2.1 and 2.2.2. When necessary, the terminology has been adjusted in order to assure correspondence between Table 1 (theory) and Sections 2.2.1 and 2.2.2 (empirical studies). Figure 1 has been also modified in line with the various changes.

(5) At some occasions, the English seems to be worth to be checked. For example, the first sentence of section 2.2.2, "Probably the first decision to study should be whether to travel anyway", should rather end with "at all".

A professional copyeditor has proofread the text. This specific suggestion has been addressed: the expression "anyway" has been substituted by "at all".

(6) One specific remark: In the introduction to behavioural economics (first and second paragraph of section 2.1): Isn't the reasoning the other way round? E.g. the article states time-inconsistent preferences (point 3) and continues with "Implications [of (3)] are hyperbolic discounting". I would see it reversely, that the (empirical) fact of hyperbolic discounting implies time-inconsistent preferences.

The reasoning and order has been reversed as suggested.

Deriving policy implications is an explicit aim of the manuscript; however, some implications are quite commonplace and generic. E.g., the need for education for environmental concern (page 8) is hardly questioned by any transport planner, even without knowledge of the underlying drivers from behavioural economics. As other examples, "Information needs to be detailed and accurate" and "...status concerns can favour car use..." in Table 3 are quite self-evident, too.

An effort has been made to provide concrete policy recommendations in Section 3 and Table 3. Regarding the example of providing environmental education, while not denying that this is accepted as relevant by many transport planners already, we feel that the arguments from behavioural economics give extra weight to it. We have now clarified this in the text.

I encourage the authors to revise or detail their policy implications with respect to their practical implementation. I am aware that as a review article, the present manuscript is restricted in its depth from going to full details; still, more specific suggestions would make the manuscript more valuable to practitioners and researchers. Some, but not all implications, which would profit from more detailed deliberation:

- Page 14, "Marketing strategies could improve the social image of green alternatives and make them fashionable." How could marketing do that?
- Table 3 suggests to "present green alternatives as defaults". How should this be implemented practically? Convincing car dealers to put only electric cars in the showroom? Requiring online search engines to rank advertisements for compact housing first?
- Page 14, "Defectors can hence be punished through public disclosure." Publication of personal information requires consent by the participants. I consider it very likely that foremost those people will participate who fear little from public disclosure, because they already act pro-environmentally.

- Page 9, "It may be important to design mechanisms that simultaneously discourage car use and encourage sustainable location choices". Could the authors propose specific mechanisms?
- Page 10, "Emissions meters could be adapted for their installation into cars" The current fuel consumption is already displayed on the speedometer of most current cars. Are there studies on the effect of this real-time feedback? They might be more relevant for the manuscript's topic than falling back on electricity consumption for household appliances.

These comments have all been addressed. Section 3 has been modified so as to provide more concrete policy recommendations. In addition, we include now examples of implementation that are relevant for transport; e.g., an example on a pilot case using a fuel-optimising navigation system is now provided.

The authors might be clearer where their implications are informed specifically from behavioral economics, and not from findings in other fields. In other words, how does the lens of behavioral economics provide a unique, previously unknown perspective on the problem? For example, findings on habits or social norms are well-established in the psychology literature. Instead of reviewing these psychological findings from a behavioral economics view: How could behavioral economics expand the psychological research agenda?

This has been addressed and we now specify in the text when a recommendation is based on insights from studies on environmental or social psychology, or alternatively it is a solution posed from the optic of behavioural economics.

In a similar vein, the manuscript places the numerous biases and heuristics equally next to each other. Could the authors provide an overview, or discuss theoretical considerations, how these biases interplay, amplify each other, or level each other out? This could be a valuable starting point for a future research agenda in this highly relevant field.

This is a very difficult question. The amplified effect of "reliability heuristic" and the "car effect" bias is now discussed in the Conclusions, where we also highlight the effect of social norms in shaping status and of affect heuristics in favouring car usage.