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Happy or Liberal? Making sense of behavior in transport policy design

Linus Mattauch
Monica Ridgway
Felix Creutzig

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Keywords

mobility behavior, behavioral economics, low-carbon transport, subjective well-being, co-benefits

Linus Mattauch/MCC/mattauch@mcc-berlin.net
Monica Ridgway/Ecologic/monica.ridgway@ecologic.eu
Felix Creutzig/MCC/creutzig@mcc-berlin.net

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Linus Mattauch [*], Monica Ridgway [†], Felix Creutzig [‡]

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Abstract

Appropriate microeconomic foundations of mobility are decisive for successful policy design in transportation, especially for the challenge of climate change mitigation. Recent research suggests that behavior in transportation cannot be adequately represented by the standard approach of revealed preferences, particularly since mobility choices are influenced by normatively irrelevant factors. Here we draw on insights from behavioral economics, psychology and welfare theory to examine how transport users make mobility decisions and when it is desirable to modify them by policy interventions. We first explore systematically which preferences, heuristics and decision processes are relevant for mobility specific behavior, such as mode choice. We highlight the influence of the infrastructure on the formation of travel preferences. Second, we argue that the behavioral account of decision-making necessitates an explicit positioning of policy-makers on whether transport policies should be justified by appealing to preference satisfaction or to maximizing subjective well-being. This distinction matters because of (i) the influence of the infrastructure on preference formation, (ii) health benefits from non-motorized mobility, (iii) commuting as a systematic source of unhappiness and (iv) status-seeking behavior. The orthodox approach of only internalizing externalities is deficient because it does not allow to evaluate these effects.

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[*](Corresponding author) Department Economics of Climate Change, Technical University of Berlin, Strasse des 17. Juni 145, D-10623 Berlin, Germany and Mercator Research Institute of Global Commons and Climate Change, Torgauer Str. 12-15, D-10829 Berlin, E-Mail: mattauch@mcc-berlin.net, Phone: 0049-(0)30-3385537-221.

[†]Ecologic Institute Berlin, Pfalzburger Strasse 43, 10717 Berlin, E-Mail: monica.ridgway@ecologic.eu

[‡]Mercator Research Institute of Global Commons and Climate Change and Deparment Economics of Climate Change, Technical University Berlin, E-Mail: creutzig@mcc-berlin.net

1 Introduction

Effective climate change mitigation necessitates the decarbonization of the transport sector (IPCC, 2014; Rothengatter et al., 2011). This challenge is arguably more difficult than the analogous transformation of the energy or the buildings sector: Mobility requires high-density fuels as opposed to electricity generation or heating (Sims et al., 2014; Pietzcker et al., 2014). Also, the emissions stemming from passenger transport result directly from the consumption decisions of the individual end-users. As such, behavioral aspects play a much more important role than, for example, in the utility sector, and, as we will argue, pose a challenge for standard neoclassical welfare theory as applied to mobility.

Options for decarbonizing transportation fall into two groups, which can be delineated with a decomposition of total GHG emissions (Schipper and Marie-Lilliu, 1999; Creutzig et al., 2011; Sims et al., 2014). Carbon and energy intensity can be reduced by technological options. This group was emphasized in former assessments on the decarbonization of transportation, e.g., Kahn Ribeiro et al. (2007). However, transport demand and modal share similarly contribute to global GHG emissions from transportation. A number of studies indicate that these factors can equally support the decarbonization of transportation (Banister, 2008; Creutzig and He, 2009; Kahn Ribeiro et al., 2012; Sims et al., 2014). While it has been argued that the second set of options can have substantial benefits in addition to reducing emissions (Woodcock et al., 2009; Creutzig and He, 2009; Creutzig et al., 2012; Shaw et al., 2014), the corresponding analyses are often not founded in economic models of decision-making and thus the welfare effects cannot be properly derived.

Here, we provide such a foundation for transport policy making when behavior becomes relevant by addressing two questions: First, can policies based on behavioral findings regarding mobility choices substantiate behavioral change as an appealing option for decarbonizing the transport sector? Second, how do two different normative viewpoints, the satisfaction of preferences and the maximization of subjective well-being, produce diverging policy conclusions? Under the paradigm of rational choice, transport economics was freed of addressing the normative distinction between maximizing subjective well-being and satisfying the preferences of transport users. The idea of preference satisfaction was seen as unproblematic – as for instance, time-inconsistent or ill-defined preferences were deemed irrelevant –, or preference satisfaction and maximizing well-being were understood to be identical. This article shows that many particular aspects of mobility behavior deviate from rational choice, and thus, our main claim is that the decision maker must take an explicit position regarding preference satisfaction or the maximization of subjective well-being: the two positions

imply different transport policies. In particular, the subjective well-being viewpoint entails a higher interaction of climate change mitigation policies in transportation with policies addressing behavioral effects unrelated to decarbonization.

As the three main achievements of this article we (i) comprehensively classify the choice mechanisms shaping mobility behavior, (ii) characterize the option space of behavioral mitigation policies in the transport sector and (iii) propose a refined and normatively explicit welfare analysis of transport policies.

First, we establish which choice-mechanisms are the main explanations for mobility-specific behavior. We systematically identify the main drivers of behavior in various modal choice situations, drawing from the large class of choice mechanisms that are well established in behavioral economics, such as time-inconsistency, social preferences, overconfidence, framing, focusing illusion, loss aversion and limited attention.

Second, our classification of choice-mechanisms involved in mobility decisions allows to exhaustively derive the option space for decarbonization policies addressing transport users' behavior. We pinpoint some of the choice mechanisms as the most promising for the design of such policy instruments. Key options include enhancing environmental awareness, addressing those behavioral factors that may lead to a higher modal share of non-motorized transport and to buying more fuel efficient cars as well as exploiting the influence of infrastructure on preferences. We highlight the importance of understanding the built environment and choice architectures as crucial leveraging factors for achieving low-carbon transport.

Third, we argue that our descriptive results indicate that understanding transport policy as internalizing the externalities of otherwise optimal behavior is insufficient. Instead, a distinction between two normative viewpoints – the maximization of subjective well-being and the maximization of preference satisfaction – is necessary in order to assess the merits of potentially beneficial side effects of decarbonization policies. The reason is that the benefits such as improved health or greater social cohesion carry greater weight when happiness is to be maximized instead of preferences being fulfilled, since transport users may not have preferences for the outcomes that make them happy. We finally delineate the differences between transport policies following from the two different welfare conceptions.

This article is connected to the pertinent literature in two ways: First, previous work on mobility choices has produced a great number of findings that highlight the importance of behavioral mechanisms for explaining mobility behavior successfully – for example, concerning mass effects and conformity behavior (Abou-Zeid et al., 2013), symbolic and affective motives for car use (Steg, 2005), inertia (van Exel, 2011) or self-value of travel (Mokhtarian and Salomon, 2001). However, such research has not given an overview of which psychological effects generally identified as important for economic

decisions matter specifically for explaining mobility (Markovits-Somogyi and Aczél, 2013). Moreover, empirical findings on mobility behavior have not been well integrated into the catalog of 'non-standard' choice-mechanisms produced by behavioral economics (DellaVigna, 2009) that are amenable to rigorous welfare analysis (van Wee et al., 2013). An exception is Avineri (2012), who also discusses the relevance of behavioral effects in mobility choices for low-carbon transport policies. However, a systematic classification of the relevant effects on choices and the distinction between subjective well-being and preference satisfaction for drawing policy implications methodically are missing.

Second, current research in welfare theory is well aware of the distinction between preference satisfaction and subjective well-being (Fleurbaey and Blanchet, 2013; Hausman, 2012; Bernheim and Rangel, 2007) but has not traced out its consequence to the field of transportation decisions and instead sought to apply it to fields such as financial decisions, health (particularly addictions), and public good problems. By contrast, studies in transport science that explicitly deal with welfare effects of (behaviorally construed) mobility decisions typically have not introduced a clear economic approach to welfare, but have chosen physical welfare metrics such as 'disability adjusted life years' (DALYs) (Woodcock et al., 2009; Shaw et al., 2014). To the best of our knowledge, no normative theories of transport policies exist to date that explicitly take into account the importance of behavioral findings regarding mobility. The valued added of our article is thus to assemble the tools for such welfare analysis of transport policy.

The remainder of this article is structured as follows: Section 2 summarizes key aspects of behavioral economics that matter for analyzing transportation decisions. Section 3 explores systematically which preferences, heuristics and decision processes identified by behavioral economics are relevant for explaining and modeling mobility specific behavior. The normative part of our analysis (Section 4) consists of three steps: First, we characterize the option space of possible behavioral decarbonization policies (Section 4.1). We then introduce preference satisfaction and subjective well-being as welfare criteria for evaluating transport policies (Section 4.2). Finally, we show why the distinction between the two criteria is relevant for designing policies and highlight the key differences between those transport policies aiming at preference satisfaction and those aiming at increasing subjective well-being (Section 4.3). Section 5 concludes by considering implications of our analysis for transportation research.

2 Behavioral economics foundations

Traditionally, economics has modeled choices of households by assuming that they maximize a utility function representing their consumption preferences. Under this assumption, households' preferences can be inferred from their observable choices. Utility is not to be understood as subjective well-being or 'happiness' (see Section 4.2), but rather as representing which options are preferred over other options. Transportation economics has adopted this perspective by modeling the preferences of transport users through observed mobility choices and narrowed it further by excluding that mobility itself is a part of the desired consumption as well (van Wee et al., 2013; Mokhtarian and Salomon, 2001): transport demand is 'demand derived' from other consumption.

Countless laboratory and field experiments have pointed to anomalies and deviations from such "rational" utility-maximization. Many of such forms of 'non-standard' behavior could, in principle, be 'rationalized', that is, understood as utility-maximizing behavior when the set of desired consumption goods is broadened or suitable 'costs' on some of the choice options are introduced (Gul and Pesendorfer, 2001, 2008). Most researchers on individual decision-making find larger departures from the paradigm of revealed preferences more convincing and believe they increase the explanatory power and accuracy of the predictions: The modeling of human decisions should make room for decision-makers to be both altruistic and envious, have partially incorrect beliefs, rely on heuristics, be influenced by factors unrelated to the consumption outcome and make mistakes in making a decision (Camerer et al., 2005; Camerer, 2008; DellaVigna, 2009; Kahneman, 2011). Analyzing the economic consequences of such behavior, both in experiments and in reality, is the subject matter of the field of behavioral economics. It seeks to find out which preferences individuals have, which beliefs they hold about states of the world and by which mechanisms they arrive at their decisions. It also seeks to understand how such behavior influences the resource allocation in markets. For the purpose of examining its relevance for mobility decisions, mechanisms underlying human choices should thus be classified into three broad categories: Preferences, beliefs and decision-making (DellaVigna, 2009). All three are indispensable ingredients to explain human choices in a satisfactory way.

First, preferences are an ordering of possible consumption options. While they are traditionally assumed to be a rational ordering of only one's own benefit of consuming the choices, individuals display a much wider set of preferences in the real world.

Second, beliefs concerning (future) states of the world and availability of options, particularly under uncertainty, are another major aspect of explaining choices. Beliefs may be correct or incorrect; systematically incorrect beliefs are called biases.

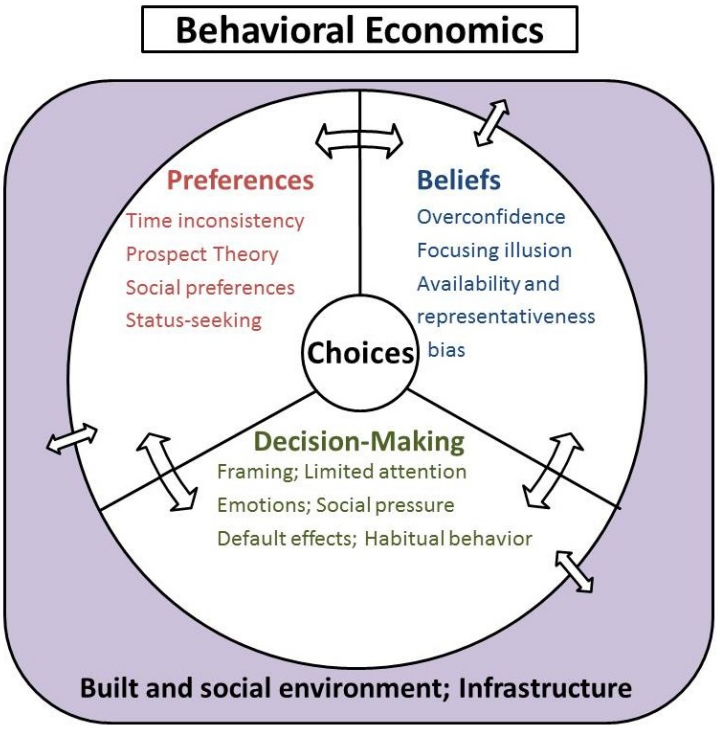

Figure 1: Concepts from behavioral economics used in this article

Third, decision-making is not always based on maximizing the utility of the outcome. One reason for this is that it is influenced by factors other than preferences and beliefs, such as the way the options are presented or the obedience of social norms. Another reason is that individuals may face informational or cognitive limitations to calculate which option would maximize their utility.

Transportation economics has implicitly taken up these concepts when analyzing mobility choices empirically, but often neglected to make explicit the nature of the underlying choice-mechanisms that lead to specific mobility behavior (van Exel, 2011; van Wee et al., 2013). However, a precise analysis of those mechanisms achieves greater clarity for drawing normative conclusions and allows designing more successful transport policies. Our analysis in the next section provides such an explicit characterization of the choice-mechanisms crucial for explaining mobility behavior. The further sections draw the normative and policy implications.

Figure 1 provides a summary of the concepts from behavioral economics used in this article and their relationships. For the role of the context of infrastructure and the built environment, see Section 3.7. Further, Appendix A.1 provides definitions of all those choice-mechanisms that haven

been identified as playing a role in mobility behavior. More detailed explanations of these mechanisms can be found in DellaVigna (2009), Gsottbauer and van den Bergh (2011) or Just (2014).

3 Classifying behavioral explanations for mobility choices

In this section we identify which types of preferences, beliefs and decision-processes shape behavior for several mobility-specific aspects. Table 1 presents a (non-exhaustive) summary of the most important relevant behavioral effects and their explanations for each mobility aspect. Subsections 3.1 to 3.6 describe which choice-mechanisms are crucial for understanding behavior regarding the mobility aspects of environmental awareness, mode choice, safety, commuting, travel time as well as car purchases and the fuel economy, respectively. For each category, relevant effects appear in the order of preferences, beliefs and decision-making. Subsection 3.7 summarizes what is known, vice versa, about the influence of the physical environment, notably infrastructure, on the formation of preferences. Implications for policy design of the choice-mechanisms identified are presented in Section 4. van Exel (2011)[chapter 2] gives a summary of the building-blocks of behavioral economics as applied to aspects of mobility, on which we draw for Subsections 3.2, 3.3 and 3.5. The reader is also encouraged to refer to the sources directly for a more in-depth analysis of the individual behavioral effects.

3.1 Environmental Awareness

The level of awareness and concern for the environment of individuals can influence their travel behavior, such as mode or route choice. Significant behavioral factors that affect an individual's awareness and concern for the environment include social preferences and framing.

Social preferences play an important part in observed behavioral shifts to sustainable mobility, which cannot be explained purely by self-interest. In some segments of the population (Anable, 2005), people's attitudes towards the environment are positively related to their willingness to reduce car use (Salomon et al., 1993; Steg and Vlek, 1997; Nilsson and Küller, 2000), as well as to their attitudes towards public transportation (Murray et al., 2010) and could be used to motivate a change in travel behavior (Anable, 2005). Indeed, some experiments indicate the existence of a "value of green", or willingness to pay for fewer emissions (for example, see (Gaker et al., 2010, 2011))[1]. This suggests that people may alter their travel decisions

[1]Two experiments were conducted. In the first, participants were given a hypothetical scenario in which they were taking a recreational trip with friends and asked to select a route out of three choices, each described by travel time, variation in travel time, toll

Mobility aspects	Particular Effects	Behavioral Explanations
Env. awareness	Willingness-to-pay for fewer emissions	Social preferences, framing
Mode choice	Habitual car use	Time-inconsistent preferences, representativeness, status quo, default effects
Safety	Safety valuation across modes, safety-compromising behavior	Prospect theory, overconfidence, emotions, social pressure
Commuting	Commuting time lowers subjective well-being	Adaptation, focusing illusion, status quo effect
Travel time	Average constant travel time, travel time valuation	Direct utility of travel, Prospect theory
Fuel economy	Undervaluation	Prospect theory
Car purchases	Lower-than-expected-search effort	Status-seeking behavior, limited attention, emotions, social pressure
Infrastructure and social context	Self-selection	Default effects, context shapes preferences

Table 1: Mobility aspects, transport-specific phenomena exemplifying behavioral effects and their behavioral explanations in terms of preferences, beliefs and decision-making processes, as used in Section 3

when provided information regarding the environmental impacts of their behavior. However, Tertoolen et al. (1998) observed that environmentally-conscious regular car drivers adjusted their attitudes, rather than behavior, and placed the blame on others instead of themselves in order to reduce cognitive dissonance associated with driving a car. Due to the potential of drivers to adjust their attitudes instead of behavior when provided environmental information, the authors argue that pro-environmental social norms are essential for the provision of information about the negative environmental effects of driving to effectively encourage more sustainable behavior (Tertoolen et al., 1998).

Framing may affect how individuals perceive the impacts of alternative

cost, greenhouse gas emissions, and safety (Gaker et al., 2010). A second revised version included a commute scenario and linked payout to decision-making (Gaker et al., 2011). The results indicated a value of green of 0.50 and 0.15 per pound CO_2 for the first and second version of the experiment, respectively.

travel choices. For instance, when presented a comparison of travel modes, individuals perceive the difference in CO_2 emissions to be larger if framed in a negative manner, that is, in terms of potential environmental damage (mode A is worse than mode B), rather than in a positive manner, or the potential benefit for the environment (mode B is better than mode A). Furthermore, the perceived difference between CO_2 emissions of the modes is amplified when presented in larger scales – for instance, a comparison of yearly outputs as opposed to a trip-by-trip presentation (Avineri and Waygood, 2013). Considering that a "value of green" may exist for some travelers, information about the impacts of alternative modes on the environment can be presented in a way that can further enhance awareness and concern.

3.2 Mode choice

Understanding how individuals make decisions regarding mode choice is vital in order to enhance the long-term sustainability of global transportation systems. Choice-mechanisms that are particularly relevant for mode decisions include time-inconsistent preferences, heuristics leading to biases, status quo and default effects as well as social norms and emotions.

Time-inconsistent preferences may explain the existence of potential self-control problems related to mode choice. This is particularly relevant for health and search costs and should be further investigated, as self-control problems have not been elucidated specifically with regard to mode choice, only regarding physical exercise more generally. For instance, active travel modes have significant positive effects on health as they reduce obesity-related diseases, as well as depression and dementia (Woodcock et al., 2009; Creutzig et al., 2012; Shaw et al., 2014). Individuals that prefer to use healthier forms of transportation in the long run could face self-control problems in the short-term, which leads them to choose a form of transportation that requires less immediate physical effort despite their long-term preference for good health and normal weight.[2]

Self-control problems could also arise when people are faced with the search costs of investigating alternative modes. Even if the costs of searching for alternative or other travel information may be more beneficial in the long run (for instance, if a former car user saves time and money by taking public transportation), agents might "underinvest" in searching for alternatives because they inconsistently value their present time now more than their future time.

[2]An individual may further exacerbate the effects of self-control issues by showing naïvety towards the problem and falsely anticipating that they will make healthier travel decisions in the future. Most people are likely *partially* naïve about their self-control problems (O'Donoghue and Rabin, 2001; DellaVigna and Malmendier, 2006).

An individual's beliefs may influence absorption of information, and subsequently behavior, regarding mode choice. In particular, the heuristics of judgment by representativeness and by availability as well as the self-serving bias have been invoked to explain habitual car-use. The presence of these biases in mobility choices necessitates a distinction between the transportation alternatives (modes and routes) available to an individual and the alternatives the individual considers to exist (labeled as the objective and subjective choice sets (van Exel, 2011), also see Mondschein et al. (2006) for a discussion on cognitive mapping). For instance, car drivers could erroneously believe that public transport is not an option for many of the trips for which it could be a viable alternative. In fact, research has identified a considerable gap between subjective (50-80 %) and objective (10-30 %) car-dependence (Goodwin, 1995, 1997).

The focusing illusion as a different bias that may also hinder car users from making correct predictions about future satisfaction with public transport. Drivers focus too much on the negative aspects of transit, such as waiting on the platform and overlook the positive ones, like reading on the train (Pedersen et al., 2011b).

Contrary to standard economic theory, people may not analyze travel decisions on a trip-by-trip basis , but rather keep the status quo derived from past evaluations, experiences, or prior commitments (Mondschein et al., 2006) which elicits a "mindless and habitual" (van Exel, 2011) approach to travel decisions. Limited attention, default effects and loss aversion contribute to habitual travel behavior (Kitamura, 2000; Verplanken et al., 1994; van Exel, 2011). The relatively low-scale commitments of holding a drivers license, owning a car or owning a season ticket (Simma and Axhausen, 2001, 2003) as well as the higher-scale commitments of residential and employment location (Ben-Akiva and Lerman, 1985; Domencich and McFadden, 1975) amplify habitual mobility behavior and can explain decisions favoring the status quo. Even when alterations make a particular route less efficient, e.g., a new construction site, repetition causes drivers to overlook these deviations and insufficiently reevaluate travel alternatives drivers stick to the old route out of habit despite the existence of better alternatives (van Exel, 2011; Kitamura, 2000; Mondschein et al., 2006; Salomon et al., 1993). Furthermore, the degree of familiarity to a transportation mode influences attitudes about the mode (Diana and Mokhtarian, 2009): also contributing to a reliance on the status quo.

Social norms and perceptions regarding different transportation modes can have a large influence on individual's decision making. For instance, perceived social support plays a considerable role in the willingness to use public transportation (Tertoolen et al., 1998; Bamberg and Schmidt, 2001; Murray et al., 2010). Similarly, motivation to drive a car is influenced by status and role beliefs (Bamberg and Schmidt, 2003).

Car driving can also generate intense feelings of identity, power, inde-

pendence, ownership, etc (Steg, 2005). These symbolic and affective aspects justify arguments against viewing car use simply as derived demand and can create barriers to behavioral changes (Steg, 2005; Anable, 2005).

3.3 Safety

Safety varies across different transportation modes (Dolan et al., 2008). Three choice mechanisms help explain mobility decisions related to safety: non-standard risk preferences, overconfidence and emotions. Moreover, for the more specific cases of wearing seatbelts and bicycle helmets, individuals decisions are also illuminated by considering a variety of behavioral factors roughly similar to that discussed in Section 3.2.

First, travelers tend to inaccurately estimate the risk of transport-related accidents occurring (de Blaeij and van Vuuren, 2003), focusing primarily on outcomes rather than probabilities, which is particularly relevant for small probabilities of large catastrophes. The actual valuation of transport-related losses is well represented by aspects of prospect theory (de Blaeij and van Vuuren, 2003). In particular, individuals value losses greater than gains and tend to overweight small probabilities and underweight large ones (Kahneman and Tversky, 1979). This could explain a higher value placed on air transportation safety compared to road safety.

Second, emotional factors, such as feelings of "dread" (Chilton et al., 2006; Sunstein, 1997; Dolan et al., 2008) "lack of control" (Dolan et al., 2008) and "ambiguity" (Bach et al., 2009), may cause perceived risks to deviate from objective risks (Slovic, 1987; Loewenstein et al., 2001). This may enhance people's willingness to pay to prevent an accident from occurring (Slovic et al., 1980) and (Carlsson et al. (2004) as cited in Dolan et al. (2008)), which has also been explained as the avoidance of "mental suffering" evoked by the image of a catastrophic plane crash (Carlsson et al., 2004).

Furthermore, individuals display overconfidence regarding their own driving and safety behavior. The majority of people believe they are more skillful than the average driver and therefore underestimate the risk of being involved in an accident (Svenson, 1981; McCormick et al., 1986). The level of overconfidence varies by age group and gender (Gosselin et al., 2010; Harre and Sibley, 2007; Ulleberg, 2001; White et al., 2011), with young males exhibiting the most overconfidence, or "comparative optimism" (Gosselin et al., 2010) in relation to their risk of being involved in (and causing) an accident. Individuals who are more overconfident and underestimate personal transportation safety risks may be less likely to respond to efforts oriented at changing safety behavior (Ulleberg, 2001).

Moreover, behavioral effects have been invoked to explain the use (and non-use) of seatbelts and bicycle helmets. For example, it has been discussed whether seatbelt wearing leads to increased risk-taking due to a change

of the reference point, that is, individuals engage more in risky behavior due to the perceived safety gained from wearing a seatbelt (Evansm et al., 1982; Janssen, 1994). Furthermore, Goudie et al. (2014) show that happier individuals are more conscientious to wear a seatbelts.

Regarding bicycle helmets, a sizeable amount of literature discusses behavioral factors that may be exploited to promote helmet wearing: Findings from the literature suggest that, similar to the mechanisms that explain persistent car use, overconfidence, biases, non-standard risks preferences as well as limited attention and social pressure prevent a higher share of helmet-wearing among cyclists (Thompson et al., 2002; Rezendes, 2006; O'Callaghan and Nausbaum, 2006).

3.4 Commuting

According to standard economic theory, agents compensate the burden of commuting with the higher utility they from their wage or housing: an individual drives a longer distance to a higher paying job or purchases a home further away from her place of work for the sake of more space (Stutzer and Frey, 2008). However, recent research finds that people with longer commutes report systematically lower subjective well-being[3] (Stutzer and Frey, 2008) due to the negative effects on people's social life (Pocock, 2003; Flood and Barbato, 2005), sleeping time, family and interpersonal relationships (Sandow, 2011) and health (Costal et al., 1988; Kluger, 1998; Evans et al., 2002)[4]. Insights from behavioral economics, therefore, may help explain this seemingly paradoxical behavior regarding commuting decisions. In particular, the misprediction of one's ability to adapt, the focusing illusion, and status quo effects are several choice-mechanisms that affect commuting behavior.

In contrast to the ability to adapt to different levels of income, people are much less able to adapt to high levels of commuting (Frey and Stutzer, 2014). Agents tend to mispredict the utility derived from large external rewards, such as a bigger house and a higher salary, and give less attention to other aspects that play a significant role in subjective well-being, such as reduced time for social life due to longer commutes and the stress caused by the commute itself (Frederick and Loewenstein, 1999; Loewenstein and Schkade, 1999). Hence individuals misleadingly focus on the utility derived from the "extrinsic" aspects of a decision, such as its impact on their income, and neglect their "intrinsic" needs, such as time spent socializing (see Frey and Stutzer (2014)). This insight makes it easier to understand why people would choose a larger living space over a shorter commute, even if it has negative effects on health or interpersonal relationships and reduces overall

[3] or the self-reported experience of the quality of one's life. See Footnote 10.

[4] For a more detailed overview of the private and social costs of commuting, see Koslowsky and Kluger (1995)

subjective well-being.[5] Recent research suggests, more specifically, that the negative effect of commuting on subjective well-being from is greatest when using a car instead of choosing an active travel mode (Martin et al., 2014), yet the details of this distinction remain unexplored.

The focusing illusion is a similar cognitive bias that refers to the tendency of people to exaggerate the "impact of any single factor on their well-being" (Kahneman et al., 2006), thereby impairing their decision-making. The focusing illusion is well documented to be relevant to income: people are highly motivated to increase their income and often justify decisions based solely on economic concerns (Frey and Stutzer, 2014) despite the weak relationship to their subjective well-being (Kahneman and Deaton, 2010).

Furthermore, due to the repetitive nature of commuting, individuals are likely to form habits and rely on the status quo when choosing a commute mode and route (Verplanken et al., 1997; Fujii et al., 2001; Verplanken and Wood, 2006). Past commuting decisions are good predictors of current behavior since people do not re-evaluate all alternatives for routine trips rather, they rely on prior assessments of alternative mode and route choices (Salomon and Mokhtarian, 1998; Mondschein et al., 2006). Limited self-control and naïvety about it further enhance the status quo effect and may lead to the 'infinite procrastination' of decisions that might reduce commuting time, such as searching for a job closer to home or an apartment closer to work (Stutzer and Frey, 2008).

3.5 Travel time

A common assumption in transportation economics is that travel demand is derived from other activities. The time spend traveling is therefore considered a cost, or disutility, that individuals seek to minimize (van Wee et al., 2013; Mokhtarian and Salomon, 2001). Several empirical findings, however, challenge this standard assumption and suggest that the direct utility derived from traveling, prospect theory and a constant average time budget need to be invoked to explain the amount of time spent on travel.

Individuals may not engage in travel merely for instrumental purposes (i.e., to reach a specific destination), but also pursue the act of travelling itself (Mokhtarian et al., 2001; Brouwer and Van Exel, 2005). The direct value of travel arises from fundamental human needs for motion, freedom or independence (Mokhtarian et al., 2001; van Exel, 2011). This means that people may not try to minimize the total time traveled as standard economic theory indicates, particularly regarding travel for recreational purposes (Mokhtarian and Salomon, 2001). Consequently, measures aimed at reducing travel

[5] Nevertheless, it is of course possible that some individuals deliberately choose to decrease their happiness through a longer commute in order to strive for other goals sought for themselves, such as meaning, power or fame through particular career options (Baumeister et al., 2013).

demand may not be as effective as expected if they do not consider the positive utility of traveling for some trips (Salomon and Mokhtarian, 1998). Furthermore, in relation to prospect theory, travel time delays are valued higher than time savings (Rietveld et al., 2001; Avineri and Bovy, 2008; Parthasarathi et al., 2011; van Exel, 2011, for an overview), as is reliability, or low variability of travel time (Bogers et al., 2008; Asensio and Matas, 2008; Tseng et al., 2009). However, it is important to note that losses refer to deviations from a specific reference point (such as a "desired" commute time (see Avineri and Bovy, 2008), arrival time, or public transportation schedule (see van Exel, 2011)), which may not reflect all objective choice sets. Considering the existence of loss aversion in terms of travel time, the occurrence of a one-time, yet substantial delay in public transportation could have long-lasting effects on the daily mode choice of an individual, even if time savings by public transportation are actually more common. Much like the distinction between subjective and objective travel choice sets, people can establish false beliefs about the reliability of a certain mode of transportation based on past experiences or attitudes (Bogers et al., 2008; Tseng et al., 2009; van Exel, 2011, for an overview).

Moreover, instead of minimizing the amount of time spent travelling (according to its dis-utility), the population is observed to have, *on average*, a fairly static daily travel time budget of approximately 70 minutes (Schafer and Victor, 2000; Hupkes, 1982; Mokhtarian and Chen, 2004, for a more skeptical view). The existence of a daily travel time budget indicates that individuals will continue to spend the same amount of time travelling despite changes in income or improvements to the availability of technology and infrastructure (Metz, 2004, 2008; Schaefer et al., 2009). This undermines the standard reasoning that providing additional transport infrastructures, for instance, by constructing highways, high-speed rail or additional airports, leads to travel time savings (Metz, 2008). In the long-run, people do not shift time savings to pursue other economic activities, but rather to reach farther destinations. The existence of a daily travel budget has implications for the outcome of certain policies and projects, such as major highway expansions. Some claim that a constant travel time budget is an anthropological invariant (Marchetti, 1994), while, in general, no encompassing explanation has been given how the aggregate constant time budget arises from individually varying travel times (Schaefer et al., 2009). It thus remains unclear whether a relatively constant travel time at the population average means that non-standard decision-making is present at the individual level.

3.6 Car purchases and fuel economy

As a major source of greenhouse gas emissions, the type of vehicles purchased by consumers is a focus of climate and energy policy. The decision-making process of car purchases is subject to a variety of behavioral factors

– particularly regarding the evaluation of fuel economy – that influence the automobile market. Research suggests that factors such as loss aversion, status-seeking behavior, social pressure, limited attention as well as emotions can affect how consumers evaluate automobile alternatives.

Under expected utility theory, a rational economic consumer consistently discounts (uncertain future) fuel costs over the entire lifetime of a vehicle when making a purchase decision (Greene, 2010). Econometric evidence, however, is inconclusive as to how consumers value fuel economy when selecting an automobile, but many such studies are conducted within the framework of rational utility maximization (Greene, 2010). For instance, Busse et al. (2013) find little evidence of unusually high discount rates with respect to fuel economy valuation.

However, others claim that there could be undervaluation of fuel economy in the automobile market due to loss aversion because of the uncertainty about future fuel prices (Greene et al., 2009). Consequently, gains in fuel savings may have to be greater than what standard utility theory would predict in order for consumers to be willing to pay a premium for automobiles with better fuel economy. Consumers may require a short payback period in order to invest in such cars.

Further, Turrentine and Kurani (2007) put more pressure on the method of estimating the undervaluation of the fuel economy based on models that assume rational individuals. They conclude, based on in-depth interviews, that "households do not have access to the basic building blocks of information regarding their fuel use and costs, [...] they demonstrate a lack of understanding or express no experience with algorithmically correct rational calculations, and [...] some demonstrate they understand such calculations but have never applied this understanding to their household vehicle purchase" (Turrentine and Kurani, 2007). Instead, they defend the hypothesis that consumers are simply inattentive to fuel economy because their decisions about purchasing cars are driven by "high value meanings, some which have important but non-quantifiable [...] value."

Indeed, social influence plays a considerable role in consumption decisions, including automobile purchases: in particular, status consumption (Layard, 2006; Clark et al., 2008; Solnick and Hemenway, 2005), may motivate buyers to purchase an automobile based on attributes such as appearance, speed or reputation (Johansson-Stenman and Martinsson, 2006; Winkelmann, 2012). Car buyers are indeed influenced by the distribution of ownership choices of their peers (Gaker et al., 2010) and, in particular, the recent automobile purchases of neighbors, which may however be rather due to information transmission than envy (Grinblatt et al., 2008). Status consumption may dilute the effectiveness of policies aimed at encouraging consumers to purchase fuel-efficient automobiles.

Rather than making automobile purchase decisions based on all available information, consumers simplify their decision-making by not optimizing

their utility over all available information, but using non-standard forms of decision-making. Several cases of limited attention in the decision-making of car buyers can be observed (Furse et al., 1984; Turrentine and Kurani, 2007):

First, people tend to utilize a two-stage decision process when purchasing an automobile (European Parliament, 2010). In the first stage, alternatives are eliminated using intuition followed by a second stage in which the person rationally weighs the alternatives. This is consistent with dual process theories about reasoning in current social and cognitive psychology (Kahneman, 2003, 2011). Such decision making process could explain large evidence for the fact that automobile buyers search effort is lower than expected (Furse et al., 1984). The characteristics that buyers consider at each stage can therefore have a large effect on the final choice. Evidence suggests that in the first stage, buyers decide on the car class based on characteristics such as price and style followed by the second stage in which they consider factors such as environmental impact and fuel economy (European Parliament, 2010). Since the environmental impact and fuel economy is relative to car class, which was decided in the first stage, these factors may not have as large as an influence on purchasing decisions as standard theory would suggest.

Second, car buyers also have a strong partial inattention to mileage in the used car market, which causes irregular drops in the sale prices of used cars at the 10,000-mile and 1,000-mile odometer thresholds (termed left-digit bias) (Lacetera et al., 2012).

Third, transaction costs and information barriers prohibit people from understanding fuel economy correctly when it is presented in complicated frames, leading to an "MPG illusion" (Larrick and Soll, 2008): car users systematically misunderstand miles per gallon (MPG) as a measure of fuel efficiency. A false linear instead of a correct hyperbolic reasoning about MPG leads car drivers to undervalue small improvements on inefficient vehicles. If expressed as gallons per mile consumers would intuitively understand their petrol use and carbon footprint[6].

Moreover, the emotional state of a person can have a large impact on consumption decisions. Car manufacturers not only sell cars based on technical features, but also tap into the emotions of potential buyers (Sheller, 2004) by emphasizing the type of lifestyle or community the car symbolizes, making it more appealing and seductive to their target market. The emotional association people have to cars (Steg, 2005) creates a barrier to reducing automobile use despite efforts to raise awareness and enhance access to public transportation (Banister, 2008).

[6](Kahneman, 2011, p. 372f.) notes that the Obama administration has partially corrected for this.

3.7 The role of infrastructure, the built environment and the social context

Infrastructure design and urban form are variables within the scope of policy design that influence individual user behavior and should thus be part of an overarching behaviorally explicit policy framework. It is commonly assumed that available transport infrastructures and spatial configurations largely determine mode choice and other mobility aspects. Important examples include the provision of cycling networks, tram lines or highways. Despite this common assumption, there is surprisingly little research that explicitly analyzes the links between infrastructure and mobility behavior, presumably because the relationship between infrastructure and preferences cannot (easily) be studied in lab experiments.

Infrastructure can influence mobility choices through two independent channels. First, it could influence behavior through framing and (ensuing) default effects in the decision-making process. Although this influence is a special case of the general ubiquity of "choice architectures" in shaping decisions (Thaler and Sunstein, 2008), there is, to the best of our knowledge, no substantial transportation research on this effect. An exception may be the finding of Bamberg et al. (2003b): individuals moving to a new city with an excellent public transport system were given information material and a free day ticket for public transport. The modal share of public transport more than doubled as a result, compared to a control group moving to the same city. This may indicate the presence of default effects (and/or limited attention) when individuals make mobility decisions in a new environment (see also Bamberg et al. (2003a)). Second, infrastructures are stocks that are effective for long time scales[7], constituting the template for preferences and user behavior. Infrastructure could thus influence the *formation* of preferences on a longer time-scale.

A recent strand of literature on social learning in transportation provides evidence for this hypothesis. Results indicate that individuals who move from city A to city B tend to have modal choice preferences that co-align with the infrastructure of city A, even if city B provides infrastructure that is more suitable for a different mode (Weinberger and Goetzke, 2010, 2011). The built environment one grows up with hence shapes one's modal preferences – preferences are not exogenous but endogenous to one's physical environment. Similarly, one's social environment may also shape individual preferences[8] (Weinberger and Goetzke, 2011; Goetzke and Weinberger, 2012). Lifestyles, impacting land-use, commuting and modal choice patterns are largely a

[7] Infrastructures alone might induce emissions in the order of the remaining carbon budget under ambitious climate protection goals (Davis et al., 2010). On a city scale, the housing sector induces inertia in long-term transport behavior and ensuing GHG emissions (Gusdorf and Hallegatte, 2007).

[8] It may however be difficult to determine whether the social environment influences the decision-making or the preference formation, similar to the case for the built environment.

result of implicit social norms of what constitutes a good life. A key example is the system of automobility that translates into a socially appropriate pattern of suburban lifestyle and car ownership (Urry, 2007).

Moreover, there is a two-way relationship between the built environment and behavioral preferences. As described, the built environment strongly impacts travel behavior (Næss, 2006; Ewing and Cervero, 2010), but the individual preference for a specific built environment, given specific mobility habits, also plays a substantial role that is not easy to quantify (Cao et al., 2009): After controlling for such residential self-selection, several studies nevertheless indicate that there is a distinct influence of the built environment on travel behavior. However, few studies have attempted to quantify the relative size of the two components' influence (see Cao et al., 2009, for an overview).

In summary, mobility preferences are revealed conditional on the availability of infrastructures. In other words, a different set of infrastructures would also lead to different revealed preferences. Normative implications of this finding are explored in the subsequent section.

4 Behavioral Transport Policy

In this section we provide a framework in which research on the effectiveness of behavioral transport policies can be carried out. In the first part, we characterize the option space of transport policies for decarbonization that address behavior. The next part of this section deals with the challenge that the behavioral account of individual choices poses to standard welfare theory and argues that two plausible candidates for defining welfare as a policy-goal emerge: a revision of the orthodox preference satisfaction approach and the maximization of subjective well-being. The last part of this section outlines the major differences in the policies that follow from the two different welfare conceptions, for example regarding commuting and infrastructure provision. Thus, the first part of this section is more "instrumental" since it asks what policies are effective *if* policy-makers want to advance decarbonization. The last two parts are more "philosophical" because they present arguments for different justifications of transport policies.

4.1 Behavioral policies for mitigating carbon emissions from transportation

Here we characterize the option space for policies addressing mobility behavior that could reduce carbon emissions, based on our overview of the major behavioral factors relevant for mobility choices (Section 3). Table 2 summarizes potential behavioral policy measures that foster low-carbon transport. We first comment on the political relevance of such measures for decarbonizing transportation before elaborating on our characterization.

We then discuss a non-exhaustive number of policies from the option space, whose effectiveness has been confirmed in practice.

Why should policies leading to changing mobility behavior be useful for climate change mitigation in transportation? Even if one believes that the ultimate solution to decarbonize the transport sector is regulation at a macroeconomic level, for instance, by including it in national cap-and-trade-systems, there are two reasons why such an analysis may be useful nevertheless. First, the high mitigation potential of a higher modal share of non-motorized transport options is unlikely to be tapped by carbon pricing alone (Banister, 2008; Creutzig et al., 2012). Therefore, behavioral mitigation policies in the transport sector can be seen as complementing, rather than substituting regulation by carbon pricing, which may be necessary, but insufficient alone to decarbonize this sector completely. Second, behavioral policies may not face the same obstacles as pricing instruments in political decision-making: no new taxes or additional costs have to be imposed on transport users for many measures. In addition, many behavioral measures need not be introduced at the national level, but can, in principle, be introduced by any level of administrative units, particularly municipalities (although coordination between them may be required). Thus, as long as national carbon pricing for transportation is politically infeasible, behavioral transport policies may be a more viable option to deliver some emission reductions. Moreover, they may also contribute to cultural shifts towards sustainable mobility that may facilitate regulation of emissions in transportation by pricing instruments.

We characterize the option space of behavioral mitigation policies as follows: For each category of mobility-specific behavior, there are many potentially successful policy instruments to consider that may reduce emissions. Policy-instruments are typically classified in three categories: (i) bans and direct regulations, (ii) monetary incentives, (iii) education and information – sometimes lightheartedly labeled "sticks, carrots and sermons" (Bemelmans-Videc et al., 1998). To these three categories, "context" must be added for the case of transport policy (Shaw et al., 2014): changing the built environment through construction or modification of the transport infrastructure alters decision-making in a way that is different from the effect of instruments from the other three categories. For each category, Table 2 gives examples of specific policy measures that may be useful for changing mobility behavior towards low-carbon options. The following list provides a summary of those measures whose effectiveness can be deduced from extant transportation research.

According to the effects described in Section 3.7, the provision of **low-carbon infrastructure** may be the most effective way to decarbonize the transport sector. It is however absent from the above list, because infrastructure design is a policy measure (see also Table 2) rather than an aspect of mobility behavior.

	Sticks (Bans, regulations)	**Carrots** (Monetary incentives)	**Sermons** (Education, information)	**Context** (Infrastructure, culture)
Env. Awareness	-	Crowding in social preferences	Salient information about emissions; provision of comparison to others	Change of cultural norms: campaigns, first adopter circles
Mode choice	Ban on cars in some parts of cities	Active choosing, free initial PT tickets	Promoting self-control; lower PT search costs; encouraging social learning about NMT	Change of built environment
Commuting	-	Commuting tax, incentives for moving close to work	Education on adaptation, personalized travel plannning	Promote more efficient use of infrastructure: car pool lanes, ...
Travel time	Ban on fast travel options	-	Inform about expected delays and alternative routes	Road diet
Fuel economy and car purchases	Fuel efficiency standards	Taxation of status aspect of cars	Active choosing in purchases, more salient information	Change cultural norms

Table 2: The option space for decarbonization policies concerning behavioral effects. "PT": public transport, "NMT": non-motorized transport

Regarding **environmental awareness**, first, providing the accumulated yearly emissions from car use compared to more sustainable modes of transportation is more effective at encouraging a change in behavior compared to daily emission savings. Also, a negatively framed comparison of emissions from different modes is more effective than a positively framed comparison (Avineri and Waygood, 2013)[9]. Second, the degree to which people feel responsible for the environmental effects of their car use, however, differs across population segments. For example, segments that show a high sense of environmental moral obligation should require less persuasion to use alternatives, such as public transportation or cycling, as long as this group is kept informed of the opportunities available to them. Information regarding traffic congestion or reliability may be more persuasive for segments that are less concerned with environmental effects (Anable, 2005). Policies will be more effective if they identify these attitudinal differences among segments of the population and frame information accordingly.

Concerning **mode choice**, the tendency to favor the status quo provides opportunities for policymakers to influence long-term travel behavior by

[9]This effect may also be applicable for other information provided i.e., calories burned, time saved waiting in traffic, etc.

motivating individuals to break undesirable habits and/or forming desirable ones. Policy measures so far tested successfully include:

- Distributing a free bus ticket to regular car users for one month. Attitudes towards the bus improved, and even one month after the end of the intervention, the frequency of car use was decreased while subjects used the bus more often and made it a habit (Fujii and Kitamura, 2003), see also Bamberg et al. (2003b).

- A temporary decrease in car use was observed after subjects with a strong habit of car use were induced to deliberate travel mode options by answering questions before beginning a trip (Garvill et al., 2003).

- A change of residence may be the most promising opportunity to alter mode choice since individuals are then forced to form new habits (Bamberg et al., 2003b; Weinberger and Goetzke, 2010).

- The establishment of social norms that are pro low-carbon transportation modes can be an effective mechanism to encourage more sustainable behavior on an individual level (Banister, 2008, for an overview).

- Finally, it is generally assumed that better infrastructure for walking and cycling promotes a higher modal share of non-motorized mobility. However, research is only beginning to examine the determinants of the efficiency of various possible changes in the infrastructure (Ogilvie et al., 2012): one tentative outcome is that new infrastructure promoting active travel may chiefly attract individuals who are physically active anyway and potentially merely displacing physical activity(Goodman et al., 2013). Over longer time-scales, however, additional active travel is generated by such infrastructure (Goodman et al., 2014).

More generally, it is confirmed that certain commitment devices can be successful against self-control problems (Brocas et al., 2004). However, there seems to be no research that applies this finding specifically to either self-control problems regarding health aspects in mode choice or investing time into exploring route and mode options.

To reduce **commuting** time, correcting misguided predictions about future satisfaction with certain modes of transportation (by increasing actual experience with public transportation, for example) could strongly influence long-term commuting behavior. After a 30-day trial period with public transportation, habitual car drivers reported a significantly greater satisfaction than they had initially expected. Satisfaction increased with the use of public transit (Pedersen et al., 2011a).

Issues of **travel time** need also to be taken into account for well-designed low-carbon transport. A first aspect is congestion: transportation planning strategies have traditionally supplied more road infrastructure to address congestion (Hanson and Giuliano, 2004), using the justification that travelers will use time savings to engage in other economic activities. As this is not the case (see Section 3.5), additional carbon-intensive infrastructure can only be justified by improved accessibility (and ensuing beneficial effects for the economy), not by travel time savings. However, this well-known aspect of transportation planning can be turned into a potentially effective strategy for climate change mitigation: as people spend a constant fraction of their time traveling on average, banning or reducing speed of carbon-intensive travel options will decrease carbon emissions. Of course, this option is only sensible if the economic costs of reduced accessibility are inessential compared to the environmental benefits. An example for this may be publicly-funded, but uneconomic local airports. A second issue is to mitigate the negative effects travel delays may have on the travelers view of the (low-carbon) public transportation system. Loss aversion regarding travel time may increase the need for measures such as informational campaigns for planned construction. This is because travelers take their preferred commuting or arrival time as well as a public transport time schedule as the reference point (see Section 3.5).

Finally, regarding **fuel economy** of cars, one policy implication is particularly salient in the literature. If loss aversion explains well why consumers do not value fuel economy highly (see Section 3.6), this provides a major behavioral rationale for fuel efficiency standards, even in addition to carbon pricing (Greene et al., 2009; Greene, 2010). An alternative suggestion voiced is to provide shorter payback periods for automobiles with better fuel economy, for example by instant rebates instead of expecting consumers to take into account long-term fuel savings.

4.2 Future normative analysis of mobility: two viewpoints of welfare

The behavioral account of how humans make economic choices renders the traditional normative approach in economics, which underlies most methods of evaluating transport policies, unconvincing (Kahneman and Sugden, 2005; Bernheim and Rangel, 2007; Loewenstein and Ubel, 2008). Several alternative approaches for evaluating economic choices, and thus welfare, are currently explored. The most important two are (i) revising the orthodox preference-satisfaction approach that maintains the idea that welfare consists in having people obtain what they want (*liberalism*); (ii) evaluating

choices by their impact on subjective well-being[10]. It has been so far unexplored what these approaches mean for the evaluation of transport policy. In this section, we present the two approaches and describe how they are to be understood in the context of transportation. We then state the main arguments for and against them.

Standard economic welfare analysis assumes that "whatever people choose makes them better off" (Loewenstein and Ubel, 2008). More generally, it is postulated that the goal of public policy, social welfare, is the (weighted) sum of the degree to which citizen's preferences are fulfilled. This normative position is called the preference-satisfaction view of welfare (Hausman, 2012): the optimality of policies is judged from this viewpoint in standard transportation economics. Research in behavioral economics and social psychology highlights two main difficulties for this normative theory: (i) preferences may be ill-defined or inconsistent, (ii) preferences may be systematically influenced by factors that one would not want to have any normative significance, notably the framing of a choice, the choice environment (such as infrastructure or the built environment in the context of transportation) or herd behavior.

Given these two difficulties, scholars have sought to modify the standard preference-satisfaction (or: liberal) approach. Revised versions try to save the idea that welfare is determined by how far human preferences can be fulfilled: they assume that preferences exist in most contexts and that it is possible to detect them. But the attempted revisions acknowledge that preferences sometimes need to be "laundered" (Hausman, 2012): not only because people may make errors in decisions or base their decisions on false beliefs, but also because of the factors highlighted in (i) and (ii) above. Thus a distinction is introduced between people's actual choices and their 'true' preferences: these are not simply revealed by the choices, but only emerge through 'purification'. The idea that preferences have to be purified in some way is for example implicit in the positions of Thaler and Sunstein (2008); Bernheim and Rangel (2009) and Hausman (2012), although there is disagreement about how exactly the purification should be carried out. A particularly prominent recent variant of this approach, for instance, is advocated by Bernheim and Rangel (2009). They respond to the challenge posed by behavioral economics to standard welfare analysis by providing formalizations of 'laundered' preferences. (For an overview over various liberal approaches to welfare that can incorporate time-inconsistent preferences, see Bernheim and Rangel (2007)). With regards to evaluating transport policy, the challenge of determining the 'true' preference of mobility-users can be

[10] The self-reported experience of the quality of one's life. For a more detailed definition as well as the reliability and validity of measures of subjective well-being commonly used in happiness economics and positive psychology, see: Kahneman and Krueger (2006); Diener et al. (2009).

particularly intricate: The effect of infrastructure and the built environment on the formation of preferences is not fully explored, but it must be assumed that the built environment shapes people's modal choice (see Section 3.7). Moreover, current culture shapes mobility decisions in favor of private motorized transportation (and so creates large externalities that cause harm in all metrics of welfare usually considered). It seems therefore unclear whether it will ever be practically possible to purify preferences about mobility of such influences and whether they should be counted as welfare.

A different approach to policy evaluation is the viewpoint that subjective well-being should be maximized. Its starting point is the well-established finding of happiness studies[11] that human beings make decisions that fail to maximize their subjective well-being (Hsee and Hastie, 2006). Welfare is taken to be subjective well-being as measured in happiness research (Kahneman, 2011, Part V), (Layard, 2011). So, difficulties with inconsistent or undefined preferences over potential choices do not exist for this approach. However, the idea that maximizing subjective well-being is often criticized as 'paternalist', because a regulator adopting this viewpoint would base its policies on what makes people happy even if they have preferences for something else. Nevertheless, it should be emphasized that freedom is an important determinant of happiness (Helliwell, 2003; Layard, 2011, ch.5) – so in practice any policy that curtails freedom is unlikely to promote subjective well-being. There is to date little research that determines the direct impact of transportation choices on happiness or the impact of happiness on mobility choices. Exceptions, however, include Stutzer and Frey (2008) on commuting as a factor of unhappiness, Abou-Zeid et al. (2012) on the impact of temporary mode switching and Ettema et al. (2012) on the impact of in-vehicle activities on subjective well-being as well as Goudie et al. (2014) on happiness as a driver of seatbelt wearing.

We now briefly summarize the main arguments for preferences-satisfaction and subjective well-being as welfare criteria. The debate has been typically framed around whether the maximization of subjective well-being is a good criterion for welfare, as preference satisfaction is the received orthodox approach in economics (Kahneman and Sugden, 2005; Kahneman, 2011; Loewenstein and Ubel, 2008; Loewenstein, 2009; Fleurbaey and Blanchet, 2013; Layard, 2011, Part III).

There seem to be two main arguments in the literature by which authors advocating preference satisfaction theories of welfare criticize subjective well-being as an alternative criterion : (i) happiness neither should be nor is de facto the only thing people care about in life. Other important life goals that are sought for themselves and not to reach greater happiness can include achievements, meaning or wisdom. (Loewenstein, 2009; Fleurbaey and Blanchet, 2013) (ii) Happiness is not a good criterion for welfare

[11] see Footnote 10.

because it is no good representation of (material) deprivation: there can be 'happy peasants and miserable millionaires' (Sen, 1985, 1999; Frederick and Loewenstein, 1999; Loewenstein and Ubel, 2008). Scholars advocating the maximization of well-being typically do so because they are skeptical that procedures for laundering preferences can be successful in practice. Against the two criticisms of subjective well-being as a welfare criterion, most seem to believe, regarding (ii), that the fact that material deprivation is not decisive for happiness implies a revision of our intuitions about welfare: curing depression should be a primary concern when mitigating inequality (Layard, 2011), and fighting poverty only in as far as it produces bad feelings. Regarding (i) advocates of subjective well-being as a welfare criterion are very skeptical about the prospect of detecting 'true' preferences. This doubt is combined with judging the idea that people want to make themselves unhappy to achieve other goals as secondary or far-fetched (Krueger et al., 2009). Alternatively, they argue that although happiness is not the only intrinsic value which makes life worthwhile (for example, meaning in life might also matter, see Baumeister et al. (2013)), it is certainly the most important one for practical purposes and thus a good first approximation for welfare in policy design (Greene, 2013).

While differences between policies aiming at maximizing subjective well-being and those aiming at preference satisfaction have been explored for the case of the health sector (Dolan and Kahneman, 2008; Loewenstein and Ubel, 2008), an analysis of the differences is lacking for the transport sector. To apply the viewpoints to transport policies, it is, first of all, crucial that both viewpoints endorse the regulation of the main externalities of motorized transportation (such as local air and noise pollution, congestion and greenhouse-gas emissions). For liberalism, correcting an externality increases welfare by the first fundamental theorem of welfare economics. Although it is not true in principle that from the viewpoint of maximizing subjective well-being correcting externalities always enhances welfare, it is true in practice for the main externalities of the transport sector due to their adverse impact on a (longer) happy life. Instead, the differences between these viewpoints concern policies that are not targeted at externalities. Thus one might think that the distinction between the two viewpoints does not matter much for transport policy. This is so because one might believe that any policy package that addresses the main externalities of road transportation effectively dominates the structure of the resulting transport system. However, important cases of mobility decisions explored in the next subsection refute this view.

	Subjective well-being	**Liberalism**
Env. awareness	Rewards for individual altruistic behavior	No particular rewards
Mode choice	Incentives for NMT, change in social norms and cues against biases	Degree of incentivizing NMT depends on type of liberalism
Safety	Disincentives for risky behavior	No disincentives for risky behavior unless: others at risk or preferences about risk inconsistent
Commuting	Disincentives for commuting	No disincentives for commuting
Car purchases	Vehicle tax according to status component of car	Imposition of 'status tax' depends on type of liberalism
Infrastructure	NMT priority, urban planning for short commutes	Not directly applicable, alternative: elicit preferences in simplest context

Table 3: Transport policies for various mobility aspects that can be justified by either maximizing subjective well-being or satisfying preferences (liberalism). "NMT": Non-motorized transport

4.3 Beyond externalities: Assessing behavioral change from two distinct viewpoints

The classification of behavioral effects introduced in Section 3 suggests that even in a transport system in which the main externalities of road transport are internalized there are many important policy choices to be made regarding the specifics of mobility – in particular concerning mode choice. We substantiate this claim by discussing four important cases in which the behavioral account of mobility choices yields different policy recommendations from the two different viewpoints on welfare: (i) the influence of infrastructure and the built environment, (ii) health benefits from non-motorized transportation, (iii) the fact that commuting causes significant unhappiness and (iv) status-seeking behavior about mobility choices. Table 3 provides a detailed summary.

First, transport infrastructure and the built environment shape people's preferences and influence how their preferences translate into choices (see Section 3.7). From the viewpoint of maximizing subjective well-being, this simply means that those infrastructures should be implemented that make the population happy. (It seems conceivable to determine the influence of various different possible transport infrastructures on the population's subjective well-being by field experiments). For liberalism, the fact that the infrastructure shapes people's preferences implies that their *actual* preferences are no sound basis for transport project appraisal. This is because if transport infrastructures influence preferences and decisions *subconsciously*, as is mostly the case, one would not want to count them as normatively

relevant. Potentially, liberal approaches could circumvent this difficulty by eliciting preferences over hypothetical residential choices or designing experiments that uncover people's true preferences over the built environment.

Second, assessing the health benefits from non-motorized transport (see Section 3.2) depends crucially on the normative viewpoint chosen. For the view that welfare consists in subjective well-being, improvements in health through more physical exercise can straightforwardly count in terms of the increased life span and happiness. (The health measures of DALYs or QALYs are related to this viewpoint.) For the view that welfare consists in the satisfaction of preferences, an assessment of such health benefits depends strongly on the normative treatment of time-inconsistent preferences (Bernheim and Rangel, 2007): is people's 'true' preference regarding modal choice in cities to opt for a comfortable drive that is adverse to their health in the long-run or is their 'true' preference to stay healthy while they are unsuccessful in getting themselves to travel by other options?

Third, should the negative impact of commuting on subjective well-being influence project appraisal or not? Commuting is a non-negligible cause of human unhappiness (see Subsection 3.4) as people systematically choose larger houses and higher salaries over more leisure time for socializing. From the viewpoint of liberalism, this effect is not relevant for transport policy. For the viewpoint of subjective well-being, one should curtail commuting (for instance, Kahneman and Krueger (2006) suggest to tax it) and also take the finding into account when assessing the merit of infrastructure projects.

Finally, the effect that there exists status-seeking behavior regarding vehicle ownership means that for the purpose of maximizing subjective well-being one would regulate such behavior because it creates an efficiency loss in subjective well-being (Layard, 2006). On the contrary, whether regulating status-seeking behavior would be mandated from the viewpoint of liberalism depends on whether one judges status-seeking as a proper externality or believes that people engage willfully in it.

Beyond the four cases described above, there may also be minor differences regarding environmental awareness and safety. As environmental awareness is typically based on altruism, fostering and crowding in such social preferences in designing environmental policies may also make the population happier, as more altruism generally leads to greater happiness (Post, 2005). Regarding safety, one may suspect that overriding preferences for risky behavior, for instance not wearing seatbelts or bicycle helmets, may increase overall happiness. However, for the viewpoint of maximizing subjective well-being, it is unclear whether the gain in healthy life years outweighs the unhappiness caused by the restricted freedom or, for the case of bicycle

helmets, in reduced modal share of cycling. Further, a potentially more important reason for distinguishing the two viewpoints in transportation is the argument that reduced motorized traffic in urban quarters leads to greater social cohesion and thus greater happiness, despite individual preferences for car-friendly road design and anonymity. We exclude it here, because the argument has not (yet) been based on specific behavioral effects.

5 Conclusion

This article presents a descriptive and normative analysis of behavioral effects in mobility decisions to improve the design and justification of transport policies. The main descriptive conclusion is that those preferences, heuristics and forms of decision-making identified by behavioral economics are indispensable to explain mobility behavior methodically. A particularly policy-relevant class of effects arises from the influence of transport infrastructures on decision-making through framing and the formation of preferences regarding mode choice. We argue that our descriptive analysis necessitates a revision of the standard approach to policy evaluation in transportation. One option is to modify the orthodox economic understanding of welfare as preference satisfaction to incorporate differences between actual and 'true' preferences of transport users. This matters particularly with regard to the influence of the infrastructure on decisions and time-inconsistent preferences regarding the health benefits of non-motorized transport. As an alternative, transport policies can be grounded on the aim of maximizing subjective well-being. Key differences to the preference approach concern status-seeking behavior and commuting, as agents systematically do not choose what makes them happy concerning these mobility aspects.

There are potential applications of our analysis to transport modeling. First, transport demand modeling may be enhanced by incorporating those behavioral effects which are particularly relevant for the given context – and this may vary widely across levels and world regions. Second, our analysis of the possible justifications for transport policies may lead to a more consistent policy design according to policy-makers' tastes. It sharpens the debate concerning trade-offs in transportation, for instance between better health and shorter commutes as opposed to greater individual liberties. Third, as long as emissions from transportation are not capped on a national level, a systematic understanding of the available behavioral options to decrease emissions emerges from our work.

Beyond the specific details of our analysis for the field of mobility, some more general lessons may emerge for behavioral economic approaches to climate change mitigation: for instance, the behavioral effects explaining why individuals have a propensity to maintain the status quo may be suspected to present obstacles for decarbonizing emissions from buildings. Moreover,

the built environment and the social context must be assumed to shape people's preferences not only about mode choice, but also about food.

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A Appendix

A.1 Behavioral effects relevant for mobility choices

The following list of choice-mechanisms standardly identified by behavioral economics is adapted from DellaVigna (2009), with some effects deleted and others added according to the relevance for mobility behavior. It contains all choice-mechanisms related to mobility behavior in the main body of this article. For implications of these effects for the theory of environmental policy see Gsottbauer and van den Bergh (2011).

1. Preferences

    - Time-inconsistency: Standard economic theory assumes time consistency, or that individuals discount the future at a constant rate at different points in time. Empirical findings, however, challenge this assumption (Loewenstein and Prelec, 1992; Frederick et al., 2002) and imply that discounting is steeper in the immediate future than in the further future, sometimes called hyperbolic discounting. Time-inconsistent preferences may induce self-control problems. Combined with naïvety, or the tendency to incorrectly believe that an activity postponed today will be completed tomorrow, self-control problems can lead to infinite procrastination, thereby explaining a "status quo bias".
    - Risk preferences: Experiments on decision-making under risk show that preferences systematically violate assumptions of expected utility theory. Prospect theory captures observed risk preferences by assuming the following characteristics: (i) reference dependence: the value of an option depends on the deviation from a reference point instead of absolute magnitude; (ii)

loss aversion: given a specific reference point, losses are valued greater than gains; (iii) diminishing sensitivity: agents are less sensitive to outcomes further from the reference point, (iv) probability weighting: decision makers tend to overweight small probabilities and underweight large probabilities. (Kahneman and Tversky, 1979)

- Social preferences: Traditional utility theory assumes individuals are purely self-interested and have a utility function based entirely on their own payoff. Decision makers, however, display altruistic behavior, which indicates that individuals also consider how their decisions affect the utility of others.
- Status-seeking behavior: Conversely, people's utility may be affected *negatively* by the consumption of others, if they care about consuming more than their reference group. Such status-seeking behavior is well-documented for a large variety of ("positional") goods. When seen as an externality, that is if it is assumed that people engage in status-seeking unintentionally, it leads to an efficiency loss in welfare (Solnick and Hemenway, 2005; Layard, 2006).

2. Beliefs

- Overconfidence: Individuals tend to overestimate their ability and quality of private information as well as underestimate the occurrence of negative events.
- Anchoring: Individuals tend to focus on the initial piece of information or cue and adjust subsequent judgments away from this anchor. Adjustments may be insufficient and the anchor may have a large influence on future assessments.
- Focusing illusion: Individuals may exaggerate the effect a specific factor has on their well-being, such as an increase in income (Kahneman et al., 2006).
- Heuristics leading to biases[12]:
  - Availability: Probability judgments are often based on memorable instances of an event, which may not be an accurate reflection of the true likelihood of its occurrence. Individuals tend to overestimate the probability of events with large consequences, familiarity, and visibility.
  - Representativeness: Individuals tend to use past experiences and established beliefs to estimate the likelihood of an outcome. But the fact that an instance is more representative of

[12]Heuristics affect choices both as beliefs (about probabilities of events) and as forms of decision-making (as substitutes for solving a maximization exercise).

a certain type of event does not make it more likely (Tversky and Kahneman, 1974).

  - "Self-serving" is a related bias: Decision makers may discount information that challenges their beliefs and support ideas that are consistent with pre-established notions (Miller and Ross, 1975).

- Misprediction of adaptation: Individuals are known to have incorrect beliefs about how far they adapt to various stimuli, for instance noise or additional income (Frederick and Loewenstein, 1999; Loewenstein and Schkade, 1999; Frey and Stutzer, 2014). In particular this is one reason why humans systematically do not choose what makes them happy (Hsee and Hastie, 2006).

3. Decision-Making

   - Framing: The manner in which a decision problem is presented affects the outcome even if economic impacts are held constant (Tversky and Kahneman, 1981).
   - Limited attention: Economic theory assumes that individuals make decisions using all information available. Empirical evidence shows, however, that individuals tend to simplify complex decisions by focusing only on a subset of information. Inattention to a specific piece of information depends on its salience and the number of competing stimuli.
   - Emotions: Decisions may be influenced by emotional states. For instance, experiments show that mood manipulations and emotional arousal substantially impact decision-making.
   - Social Pressure: The desire to conform can lead to an excessive impact of the beliefs of others on an individual's decision making and may lead to herd behavior. Further, (irrational) persuasion can also occur when a decision maker underestimates the incentives of the information provider.
   - Default effects: In order to simplify complex decisions, individuals may avoid making an active choice and instead favor the default option. This can be due to having a preference for the familiar and/or salient in difficult choice situations. Often, framing influences individuals' propensity to choose the default. Together with loss aversion and limited attention, this form of decision-making can in particular lead to choosing the status quo as the default.

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