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Shedding light on the psychological and behavioral determinants of travel mode choice: A meta-analysis

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ABSTRACT

Mobility represents a relevant topic from the standpoint of environmental degradation, health-related consequences and social inclusion. Since private mobility is responsible for the greatest share of polluting emissions, it is necessary to gain deeper understanding of the mechanisms underpinning the choice of individuals to use either cars or alternative, environment-friendly transport modes. A meta-analysis on 58 primary studies is conducted to synthesize evidence on the determinants of travel mode choice, as regards both behavioral intentions and actual behaviors. Results suggest that, besides intentions, habits and past use represent the most relevant predictor, followed by constructs referring to the Theory of Planned Behavior framework. Environmental variables, on the other hand, play a relevant role in shaping behavioral intentions while their effect on actual behaviors is negligible, so that a deep intention behavior gap emerges. A moderator analysis is performed to explain the high heterogeneity in the results. Behaviors' operationalization and measurement emerges as the moderator affecting heterogeneity of outcomes the most; trip purpose, sample type and year of the study also show a moderate effect on heterogeneity, while location does not appear to be a relevant moderator.

1. Introduction

There is wide consensus over the un-sustainability of current mobility patterns, and the need to shift towards new paradigms (Collins & Chambers, 2005; Gardner & Stern, 2008; Stern, 2011). The transport sector is indeed responsible for problems ranging from air pollution and climate change (Oskamp, 2000) to health related issues (Peters et al., 2004), and even to social exclusion/accessibility (Geurs & Van Wee, 2004).

Transportation currently accounts for around 14% of greenhouse gas (GHG) emissions on global scale (IPCC, 2014). In the EU 28, transport in 2013 accounted for 22.2% of GHG emissions, up from 14.9% in 1990 (Eurostat tables[1]). Moreover, unlike other industrial sectors, transport did not reduce emissions although after the peak of 2007 the trend started to change due to increasing oil prices and diminishing activity by freight vehicles as a consequence of the economic downturn. Similarly in the US, transport accounted for 26% of GHG emissions in 2014, with a sensible increase since 1990 (EPA, 2016). Until recently, the environmental impacts of transportation have been an issue affecting western countries. However, emerging economies are experiencing a steady increase so that the contribution to emissions deriving from transport sector is bound to rise over the

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[1] Eurostat, European Environment Agency, European Topic Centre on Air and Climate Change http://ec.europa.eu/eurostat/statistics-explained/index.php/Greenhouse_gas_emission_statistics.

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next years. China represents a striking example (Gambhir, Lawrence, Tong, & Martinez-Botas, 2015): vehicle sales rose from 2.1 million in 2000 to 23.5 million in 2014 (CAAM, 2015), with private vehicles and freight respectively responsible for 5% and 8% of GHG emissions, and on the increase (Hao, Geng, Li, & Guo, 2015; Hao, Liu, Zhao, Li, & Hang, 2015). India has still low figures as regards private cars (with on the other hand many two-wheeler vehicles), yet it is projected to become the third world's largest automobile market, with a rapid growth especially in the segment of small vehicles (Altenburg, Schamp, & Chaudhary, 2015).

The shift towards sustainable mobility represents a complex issue where various solutions and pathways (either in synergy or in alternative) can be envisaged, encompassing an active role played by different actors and stakeholders. For instance, the automotive industry can propose new or improved technologies capable of curbing the environmental impacts of mobility (e.g., new vehicles such as EVs or the improvement of the efficiency of conventional engines). Local authorities can adopt plans for sustainable mobility in urban areas (like so called SUMPs, Sustainable Urban Mobility Plans) focusing on new infrastructures, improved public transportation or even congestion charges. Policy makers at national and international level can implement standards and regulations to drive the change by means of a top-down approach (e.g., the Fuel Quality Directive, European Commission, 2009). However, citizens represent the key-actor whose involvement is necessary for any sustainable mobility strategy to succeed (Donald, Cooper, & Conchie, 2014): private mobility is a crucial contributor of CO_2 and other pollutants' emissions with detrimental impacts especially in urban areas (Dulal & Akbar, 2013), and psychological drivers of behavioral change proved to be more effective than infrastructural changes in addressing the issue (Hunecke, Haustein, Böhler, & Grischkat, 2010). Indeed, there is growing awareness that transport policies aiming at reducing car use can be accomplished by focusing on the psychological constructs of commuters (Möser & Bamberg, 2008). It is hence necessary to understand the relevance of different drivers capable of spurring the adoption of sustainable mobility patterns.

The present study focuses on the determinants of travel mode choice and the psychological and behavioral correlates of car vs. non-car use. Since existing literature is not conclusive and different studies reach inconsistent results on the main predictors of (sustainable) mobility, we perform a meta-analysis to synthesize existing quantitative research on the topic. To the knowledge of the authors, only one comprehensive meta-analysis on travel modes has been carried out, based on a 2006 database (Gardner & Abraham, 2008) and representing the starting-point of the present research. Indeed, our study provides a contribution to the ongoing debate by (i) including recent and current research, (ii) broadening the scope of analysis as to encompass further predictors and new perspectives of analysis (which will be described in the methods section) and (iii) investigating possible explanations of the variability across studies, by means of heterogeneity analysis. Our concluding remarks highlight the implications of the results of the meta-analysis, and propose preliminary ideas for future research.

2. Theoretical models

Different theoretical frameworks have been applied to investigate travel mode choice, with different degrees of complexity and predictive capability, the most popular of which is represented by the Theory of Planned Behavior (TPB, Ajzen, 1991). TPB is broad in scope and is not born out of environmental research; however, it is very useful to investigate sustainability related domains, including mobility. The theory holds that intentions are the closest antecedents of behavior and have, in turn, three main predictors: attitudes, subjective norms and perceived behavioral control (PBC). Attitudes represent the personal desirability of a behavior, or the feeling of being more or less favorable towards performing the activity. As regards mobility, I might have a positive attitude towards, say, commuting by means of public transportation because I believe that it is nice to contribute to environmental protection through my daily activities. Subjective norms refer to the social pressure we experience: do people who are relevant to me expect that I adopt a specific behavior? That is, for instance: do I feel pressure from my peers and relevant ones to commute by means of environment-friendly transport modes? PBC has been added to the original framework of the Theory of Reasoned Action (TRA, Fishbein & Ajzen, 1975) as a third predictor of behavioral intentions (and thus behaviors): it accounts for the perceptions of how difficult or easy it is to perform a behavior, representing the answer to speculations that behaviors are not completely under volitional control as originally suggested by TRA. In our example, I might hold positive attitudes and feel social pressure towards sustainable means of commuting, yet I might feel that such behavior is too difficult to adopt, this leading to an attitude-behavior gap (Kollmuss & Agyeman, 2002; Lane & Potter, 2007).

TPB has been adopted by a number of studies analyzing the determinants of travel mode (Harland, Staats, & Wilke, 1999; Klöckner & Matthies, 2009; Lois, Moriano, & Rondinella, 2015; Noblet, Thøgersen, & Teisl, 2014; Nordfjærn, Şimşekoğlu, & Rundmo, 2014; Polk, 2003). Further variables have been included to integrate the original framework, as to increase the explanatory power of the model: for instance, we can here mention habits (Bamberg & Schmidt, 2003; Donald et al., 2014; Verplanken, Aarts, van Knippenberg, & Moonen, 1998), role beliefs (Bamberg & Schmidt, 2003), personal norms (Manstead & Parker, 1995; Parker, Manstead, & Stradling, 1995) and descriptive norms (Donald et al., 2014; Heath & Gifford, 2002). While the predictive capability of TPB proved to be good (Armitage & Conner, 2001; Sutton, 1998), the relative importance of the constructs as antecedents of travel mode choice varies across studies (Gardner & Abraham, 2008).

A second stream of research on transport mode focuses on "feelings of moral obligation to perform or refrain from specific actions" (Schwartz & Howard, 1981, page 191). Such constructs, which have been suggested as a relevant driver of pro-environmental behaviors, have been labeled as personal norms, moral norms or other equivalent formulations (Conner &

Armitage, 1998). According to Norm-Activation-Theory or Model (NAM, Schwartz, 1977), personal norms get *activated* by variables such as awareness of the adverse consequences of not adopting the virtuous behavior (awareness of consequences) or the ascription of responsibility reflecting feelings of being accountable for such negative outcome (ascription of responsibility).

Moral obligations represent the basis of other psychological theories on consumer behavior such as Value-Belief-Norm (VBN) Theory (Stern, 2000; Stern, Dietz, Abel, Guagnano, & Kalof, 1999), which integrates the work of Schwartz on values (Schwartz, 1992), NAM and the New Ecological Paradigm (NEP, Dunlap & Van Liere, 1978). In the words of Schwartz (1994), values are "a desirable trans situational goal varying in importance, which serves as a guiding principle in the life of a person or other social entity" (page 21). NEP, on the other hand, focuses on beliefs in the limit of growth and the need to preserve natural balance endangered by reckless development of human activities; it represents a widely adopted measure of pro-environmental orientation (Dunlap, Van Liere, Mertig, & Jones, 2000). VBN suggests focusing on a chain of variables, from general pro-environmental values and concern to specific beliefs on the consequences of certain activities, and the responsibility of individuals to avoid such detrimental consequences: sustainable personal norms for pro-environmental behavior should be activated, guiding individuals towards greener behavioral patterns.

A third stream of research on pro-environmental behaviors is represented by habits (here analyzed outside of TPB-based frameworks), which assume particular relevance for mobility since behaviors are performed in stable contexts and decisional settings (Aarts & Dijksterhuis, 2000; Verplanken, Aarts, van Knippenberg, & van Knippenberg, 1994). According to the Theory of Interpersonal Behavior (Triandis, 1977), when individuals frequently perform a given behavior in response to a specific goal (like commuting to work, university or shopping) behavioral intentions no longer act as the main predictor of behavior itself. Habits hence represent an independent determinant of behavior (Bamberg & Schmidt, 2003), moderating the intention-behavior relationship (Verplanken et al., 1998). Whereas habit has been sometimes used as a synonym of (or at least as a construct very close to) past behavior (Triandis, 1980), consistently with recent literature we consider the former as a more complex construct: habits represent goal-oriented scripts that are based on repeated behaviors and carried out in stable contexts (Ouellette & Wood, 1998; Verplanken & Aarts, 1999). We hence focus on past behaviors and habits as distinct predictors of given travel mode choices.

Albeit planned behavior, values and habits represent the three principal streams of research on travel modes, there are other variables that have been investigated in literature, and need to be taken into consideration. For instance, not only subjective (sometimes referred to as injunctive, or social) and personal (moral) norms but also descriptive norms can represent relevant predictors of intentions and behaviors. Descriptive norms represent typical and normal behaviors, *what people do* in a given situation (Cialdini, Kallgren, & Reno, 1991; Cialdini, Reno, & Kallgren, 1990): the perception of how people behave represents a motivation to do the same, providing "evidence as to what will likely be effective and adaptive action" (Cialdini et al., 1990, page 1015). Personal norms might be activated by problem awareness and by environmental values (Nordlund & Garvill, 2003), which can also be considered as predictors of pro-environmental behaviors including mobility. Another example is represented by the Technology Acceptance Model (TAM, Davis, 1989), precursor of TRA and TPB, which suggests that perceived usefulness and perceived ease of use explain attitudes, which in turn explain behavioral intentions and actual behaviors.

Other theoretical frameworks stemming from the Model of Material Possession (Dittmar, 1992) focus on the functions that possessing specific goods such as private cars can fulfill. Instrumental motives have been object of most early research, as they relate to traditional dimensions such as convenience, speed or flexibility. Indeed, most research focused on examining the rational, instrumental benefits of private car use over public transport or other environment-friendly transport modes: empirical evidence suggested that most individuals tend to choose private cars as they believe it is faster, more accessible and reliable (Gatersleben, 2011). Recently researchers are explicitly studying also symbolic and affective motives, which relate to the identity of the self and the social position, and to emotions evoked by driving cars, respectively (Steg, 2005). These different motives can be linked to (and are the subject of) previously mentioned psychological theories. TPB for instance focuses on instrumental motives and on some specific social motives: most studies investigating attitudes focus on the instrumental consequences of car use, while subjective norms refer to the motivation to comply with expectations of reference groups, thus reflecting symbolic factors. Also other theories focused on social and symbolic motives, such as the Theory of Normative Conduct (Cialdini et al., 1991), Social Comparison Theory (Festinger, 1954; Masters & Smith, 1987) and Self-presentation Theory (Schlenker, 1980), while some authors focus on the affect-driven dimension, suggesting that driving (or choosing different transport modes) evokes emotions that are anticipated in the decision process, thus determining modal choice (Manstead & Parker, 1995).

3. Methods

The aim of this study is to synthesize empirical evidence on the determinants of travel mode choice, as regards both private car and environment-friendly alternatives: we label them as *car* and *non-car* (*green*), respectively.[2]

We first identified studies focusing on travel behavior (intention) using the internet search machine Google Scholar and the Web of Science, EBSCOhost, Scopus, and ScienceDirect databases. Search keywords were terms referring to travel modes,

[2] Green transport modes include public transport, bicycles, walking and reduction in (intention/ willingness to reduce) car use and carpooling.

theoretical frameworks with respective determinants plus synonyms and/or combinations (see Appendix). After this preliminary search, 185 titles were selected as potential candidates for inclusion: abstracts and methodology sections were checked to identify whether studies were eligible for our research, leaving us with 73 studies. We read them and manually added 13 more articles adopting an ancestry approach.[3] After a case-by-case discussion with an external expert in the field,[4] who also replicated the search with relevant key-words for a further cross-check, we excluded 10 studies either because (i) they focus on the adoption of innovative technologies such as electric vehicles rather than on travel mode choice (e.g., Lai, Liu, Sun, Zhang, & Xu, 2015), (ii) they address active transportation for leisure time or health-related issues, so that car is not an alternative (e.g., Lee & Shepley, 2012), (iii) their sample consists of a very specific group hindering generalizability of findings (e.g., Murtagh, Rowe, Elliott, McMinn, & Nelson, 2012). Lastly, 25 studies failing to report the quantitative information needed for the meta-analysis (bivariate Pearson correlations and sample sizes) were dropped. The final database (see Table 1) is hence based on 51 articles, 7 of which providing two independent samples datasets, for a total of 58 sample studies (n = 58).

As regards the meta-analytic strategy, we extracted 13 determinants of behavior and 13 determinants of intention from the selected studies.[5] Based on the operational definitions of constructs, the determinants of travel mode choice are treated separately for car and non-car. We hence obtain four outcome (dependent) variables for the meta-analysis: car use behavior, non-car use behavior, car use intention and non-car use intention. For studies including more than one behavioral measure from the same sample, reporting separate bivariate correlations for each measure (e.g., Noblet et al., 2014; Steg and Sievers, 2000), the weighted average correlation of the behaviors within the study is used as a unit of analysis; this is done to follow the independence assumption underlying the validity of meta-analytic procedures.

For all computations and analyses, the statistical software Comprehensive Meta Analysis 3.3 was used. We first perform effect size analysis based on the correlation coefficients extracted from sample studies, pooling the effects from primary studies to assess the overall effect size of each independent variable on the dependent variables (Field, 2005). Following Hedges and Olkin (1985), we apply the Fisher's Z score transformation to calculate the weighted average correlation and to assign weights to individual effect sizes (for the specific formulas and a thorough description of the methodology, see Hedges and Olkin (1985) and Hedges and Vevea (1998)). Weights of individual effect sizes are assigned based upon the studies' sample sizes, with standard error and sample variance being calculated during the process; the significance of the effect size is measured by the *Z*-test and the precision of the pooled effect size is estimated by the 95% confidence intervals.

Heterogeneity of results is tested through *I-squared,* which describes the percentage of variation across studies that is due to true differences in effect sizes rather than chance (Higgins, Thompson, Deeks, & Altman, 2003). There is no clear consensus among researchers on the adequacy of fixed vs. random effect model for the effect size calculation (Field, 2005): while the former assumes a fixed weight for a specific study, the latter assumes that effect size varies randomly across studies. Consistently with most research in social sciences and following the argument of Hedges and Vevea (1998) about the inability of fixed effect methodology results to be generalized, we apply random effect methodology.

Moreover, robustness of findings against publication bias is assessed by calculating the fail-safe N, which represents the number of missing studies averaging a *Z*-value of zero that should be added to yield a statistically insignificant overall effect size (Rosenthal, 1984).

4. Results and discussion

Meta-analysis results are presented in Tables 2–5, illustrating the correlates of four outcome variables: behaviors and behavioral intentions as regards both private car use (car) and alternative, environment-friendly transport modes (green).

The first piece of information emerging from the analysis is represented by the *combined* effect size $\hat{r}$, which according to rules of thumb in literature (Cohen, 1992) is considered large, medium and small at the .50, .30 and .10 marks, respectively.

Consistently with the TPB framework, according to which intentions are the main antecedents of behaviors and have in turn attitudes, norms and PBC as predictors, the meta-analysis confirms that indeed intentions[6] represent the main predictor of travel mode choice. In literature, intentions and actual behaviors are sometimes collapsed in one single, overarching construct. Notwithstanding the overlapping and correlations between the two, however, we strongly suggest disentangling them: it is indeed of paramount importance to analyze in details the intention-behavior gap (Sheeran, 2002), and which drivers and predictors vary significantly in relevance according to a focus on either intentions or actual behaviors.

Besides intentions, habits and past use represent the main predictors, showing the highest correlations both with intentions and actual behaviors. Results corroborate speculations that especially in a domain characterized by stable context and settings such as commuting to work or to shopping (Aarts & Dijksterhuis, 2000), there is a strong path dependency that heavily affects our mobility-related choices (Aarts, Verplanken, & Knippenberg, 1998). This has relevant implications for policies

[3] An ancestry approach is a methodology widely adopted in literature reviews and meta-analyses in which the bibliographies and reference sections of studies already retrieved are used to locate earlier relevant studies (the "ancestors").

[4] A University faculty member with specific expertise and international publications in meta-analyses in the domain of sustainability.

[5] These determinants are attitude, injunctive (subjective/social) norm, descriptive norm, personal moral norm, perceived behavioral control, habit, past use, problem awareness, awareness of consequences, ascription of responsibility, environmental concern, environmental values, perceived usefulness, and intention (when behavior is the dependent variable). Personal and moral norms are merged as studies included in the analysis often use them interchangeably (Gardner & Abraham, 2008).

[6] when analyzed as predictors, and not as outcome – dependent variables.

Table 1
Characteristics of study dataset.

Primary studies	Theory applied	Outcome variable(s)	Sample size	Country
Abrahamse, Steg, Gifford, and Vlek (2009)	NAM, TPB	Frequency of car trips, intention to reduce car use	241	Canada
Baldassare and Katz (1992)	N/A	Frequency of reduced driving	641	USA
Bamberg, Ajzen, and Schmidt (2003)	TPB, habit	Bus use; intention to use bus	1874	Germany
Bamberg et al. (2007)[a]	NAM, TPB	PT use; intention to use PT	796, 437	Germany
Carrus, Passafaro, and Bonnes (2008)	MGB	Intention to use PT	180	Italy
Chen and Chao (2011)	TPB, TAM, Habit	Intention to use PT	442	Taiwan
Cools et al. (2011)	TDM, NAM, VBN	Willingness to reduce negative effects of car use	300	Belgium
de Bruijn, Kremers, Schaalma, Van Mechelen, and Brug (2005)	TPB	Frequency of bicycle use; intention to use bicycle	3859	Netherlands
de Bruijn, Kremers, Singh, Van den Putte, and Van Mechelen (2009)	TPB	Average cycling time; intention to use bicycle	317	Netherlands
De Groot and Steg (2007)[a]	TPB(extended)	Intention to use transferium	68, 150	Netherlands
De Groot, Steg, and Dicke (2008)	NAM	Intention to reduce car use	489	5 EU Countries
Donald et al. (2014)	TPB (extended)	Car and PT use; intention to use car and PT	827	UK
Eriksson and Forward (2011)	TPB	Intention to use car and other modes	620	Sweden
Eriksson et al. (2006)[a]	TDM, VBN	Willingness to reduce car use	462, 460	Sweden
Eriksson, Garvill, and Nordlund (2008)	VBN, Habit	Frequency of car trips	71	Sweden
Forward (2014)	TPB, TTM, habit	Willingness to bike	414	Sweden
Friedrichsmeier, Matthies, and Klöckner (2013)	Habit	% of car use; intention to use car	1048	Germany
Fujii (2006)	TPB (extended)	Intention to reduce car use	341	Japan
Gardner (2009)[a]	Habit, motivation	% of car & bicycle trips; intention to use car & bicycle	107, 102	UK, Netherlands
Gardner and Abraham (2010)	TPB	Proportion of car to non-car use; intention to use car	190	UK
Gärling et al. (2001)[a]	N/A	Car use frequency; car preference (hypothetical scenario)	60, 48	Sweden
Garvill, Marell, and Nordlund (2003)	Attitude, Habit	Car use frequency	115	Sweden
Harland et al. (1999)	TPB, NAM	Intention to use other modes than car	305	Netherlands
Haustein and Hunecke (2007)	TPB (extended)	% of actual use; intention to use other modes	1545	Germany
Haustein, Klöckner, and Blöbaum (2009)	TPB, NAM	% of car use; intention to use PT	2612	Germany
Heath and Gifford (2002)	TPB, NAM	Percentage of bus use; intention to use bus	175	Canada
Hsiao and Yang (2010)	TPB (extended)	Willingness to take high speed rail	300	Taiwan
Joireman, Van Lange, Kuhlman, Van Vugt, and Shelley (1997)	Interdependence theory	Preference of car vs. other modes (hypothetical scenario)	102	Netherlands
Kaiser, Ranney, Hartig, and Bowler (1999)[a]	Rational choice, NAM	Intention for pro-environment travel behavior	436, 488	Switzerland, USA
Klöckner and Matthies (2009)	NAM, TPB, habit	Ratio of car trips to all trips	430	Germany
Lo et al. (2016)[a]	TPB, PN, habit	Frequency of car use; intention to use car	452, 386	Netherlands
Lois et al. (2015)	TPB, TTM	Intention for cycle commuting	595	Spain
Loukopoulos and Gärling (2005)	N/A	Driving frequency; walking frequency	155	Sweden
Mann and Abraham (2012)	TPB (extended)	Car and PT use; intention to use car and PT	229	UK
Nilsson and Küller (2000)	Attitude	Distance driven by car during the previous year	421	Sweden
Noblet et al. (2014)	TPB (extended)	Attempts to drive less and use of alternative modes	1340	USA
Nordlund and Garvill (2002)	NAM	Pro-environmental travel behavior	1414	Sweden
Nordlund and Garvill (2003)	NAM, VBN	Willingness to reduce car use	1467	Sweden
Nordlund and Westin (2013)	TPB, VBN, NAM	Intention to use train	1238	Sweden
Onwezen, Antonides, and Bartels (2013)	NAM, TPB	Frequency of bike and PT use	617	Netherlands
Passafaro et al. (2014)	MGB	Desire to use bicycle	387	Italy
Polk (2003)	TPB, habit	Regular car use, willingness to reduce car use	1180	Sweden
Staats, Harland, and Wilke (2004)	TPB, habit	Intention to use travel modes other than car	150	Netherlands
Steg (2004, 2005)	TPB, TNC	Percentage of car trips	113	Netherlands
Steg and Sievers (2000)	Cultural theory	Annual distance driven by car; proportion of car vs. other modes	269	Netherlands
Tanner (1999)	ITB	Frequency of car use	153	Switzerland
Thøgersen (2006)	NAM, SDT, CMDT	Frequency of PT use	810	Denmark
Van Vugt, Meertens, and Lange (1995)	Interdependence theory	Preference of car vs. other modes (hypothetical scenario)	56	Netherlands
Verplanken et al. (1994)	Attitude, Habit	Frequency of car use	199	Netherlands
Verplanken et al. (1998)	TPB, Habit	Ratio of car use to other modes; intention to use car	200	Netherlands

(*continued on next page*)

Table 1 (*continued*)

Primary studies	Theory applied	Outcome variable(s)	Sample size	Country
Yang-Wallentin, Schmidt, Davidov, and Bamberg (2004)	TPB	Percentage of PT use; intention to use PT	912	Germany

Note: CMDT = Cognitive moral development theory (Kohlberg, 1984), ITB = Ipsative theory of behavior (Frey, 1988), NAM = Norm activation model (Schwartz, 1977; Schwartz & Howard, 1981), SDT = Self-determination theory (Deci & Ryan, 1985), TAM = Technology acceptance model (Davis, 1989), TDM = Travel demand management measures, TNC = Theory of normative conduct (Cialdini et al., 1990, 1991), TPB = Theory of planned behavior (Ajzen, 1985, 1991), VBN = Value-belief-norm (Stern, 2000; Stern et al., 1999), MGB = Model of goal-directed behavior (Perugini & Bagozzi, 2001), N/A = not available.

[a] Authors conducted two independent studies.

Table 2
Effect size analyses of correlates of car use.

Variables	K	Sample	$\hat{r}$	Z-value	95% C.I.		I^2
ATT (car)	15	4290	0.406	6.012***	0.282	0.516	96.642
ATT (green)	7	3283	−0.358	−3.739***	−0.516	−0.176	96.673
INJ. N. (car)	10	2866	0.229	3.598***	0.117	0.335	88.771
INJ. N (green)	3	3681	−0.153	−3.250***	−0.243	−0.061	71.444
DES. N. (car)	6	2199	0.255	1.766*	−0.029	0.500	97.681
PER. N. (car)	3	1655	0.362	15.419***	0.319	0.403	0.000
PER. N. (green)	7	4222	−0.262	−4.120***	−0.376	−0.140	87.424
PBC (car use)	7	2399	0.27	2.832***	0.085	0.437	95.183
PBC (green)	4	1092	−0.429	−2.714**	−0.659	−0.127	96.623
AWAR. CONS.	2	671	−0.130	−1.076 n.s.	−0.352	0.107	88.865
PROB. AWAR.	8	5545	−0.17	−4.237***	−0.250	−0.094	82.76
ASC. RESP.	3	644	−0.144	−1.037 n.s.	−0.397	0.129	91.632
ENV. CONC.	4	2621	−0.195	−2.975***	−0.316	−0.067	89.850
HABIT (car)	17	8098	0.416	5.967***	0.289	0.529	97.111
Past car use	6	1699	0.686	5.150***	0.478	0.821	96.683
INT. (car)	8	3441	0.825	6.286***	0.668	0.912	99.084
INT. (green)	2	3300	−0.511	−2.251**	−0.784	−0.073	98.197

K = number of outcomes from sample studies; $\hat{r}$ = overall effect size; C.I. = confidence interval; I^2 = I-squared.
ATT = attitudes; INJ. N. = injunctive norms; DES. N. = descriptive norms; PER. N. = personal norms; PBC = perceived behavioral control; AWAR. CONS. = awareness of consequences; PROB. AWAR. = problem awareness; ASC. RESP. = ascription of responsibility; ENV. CONC: = environmental concern; INT. = intention.
n.s. non-significant.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

Table 3
Effect size analyses of correlates of non-car use.

Variables	K	Sample	$\hat{r}$	Z-value	95% C.I.		I^2
ATT (green)	12	13282	0.313	8.689***	0.245	0.377	93.812
INJ. N. (green)	12	12737	0.234	7.773***	0.177	0.291	90.305
DES. N. (green)	4	2231	0.214	2.375**	0.038	0.377	93.553
PER. N. (green)	9	6216	0.336	6.533***	0.24	0.425	93.983
PBC (green)	12	12649	0.376	7.643***	0.286	0.460	96.687
AWAR. CONS.	3	1571	0.125	1.729*	−0.017	0.263	87.827
PROB. AWAR.	5	2698	0.196	3.127***	0.074	0.312	88.112
ASC. RESP.	4	1746	0.223	4.051***	0.122	0.339	82.018
ENV. CONC.	3	936	0.139	4.563***	0.079	0.197	59.635
HABIT (green)	2	929	0.683	2.005**	0.019	0.929	98.367
Past non-car use	3	2205	0.846	5.741***	0.674	0.931	97.493
ENV. VAL.	4	4417	0.140	1.456 n.s.	−0.049	0.319	97.298
INT (green)	12	11411	0.617	7.308***	0.484	0.723	98.977

K = number of outcomes from sample studies; $\hat{r}$ = overall effect size; C.I. = confidence interval; I^2 = I-squared.
ATT = attitudes; INJ. N. = injunctive norms; DES. N. = descriptive norms; PER. N. = personal norms; PBC = perceived behavioral control; AWAR. CONS. = awareness of consequences; PROB. AWAR. = problem awareness; ASC. RESP. = ascription of responsibility; ENV. CONC: = environmental concern; ENV. VAL. = environmental values; INT. = intention.
n.s. non-significant.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

Table 4
Effect size analyses of correlates of intention to use car.

Variables	K	Sample	$\hat{r}$	Z-value	95% CI		I^2
ATT (car)	7	2906	0.563	5.916^{***}	0.402	0.690	96.832
ATT (green)	4	1483	−0.530	-4.021^{***}	−0.705	−0.294	96.743
INJ. N. (car)	7	2906	0.424	7.749^{***}	0.326	0.513	89.066
DES. N. (car)	6	2706	0.272	1.968^{**}	0.001	0.506	98.048
PER. N. (car)	3	1665	0.394	16.953^{***}	0.353	0.434	0.000
PER. N. (green)	2	421	−0.512	-11.520^{***}	−0.580	−0.438	0.000
PBC (car)	7	2906	0.322	3.088^{***}	0.121	0.498	96.867
PBC (green)	2	421	−0.452	-4.077^{***}	−0.617	−0.247	82.950
ENV. CONC.	3	1103	−0.259	-8.434^{***}	−0.315	−0.201	0.000
HABIT (car)	7	4068	0.472	7.195^{***}	0.357	0.573	94.612
Past car use	4	1584	0.739	3.471^{***}	0.391	0.902	98.762

K = number of outcomes from sample studies; $\hat{r}$ = overall effect size; C.I. = confidence interval; I^2 = I-squared.
ATT = attitudes; INJ. N. = injunctive norms; DES. N. = descriptive norms; PER. N. = personal norms; PBC = perceived behavioral control; AWAR. CONS. = awareness of consequences; PROB. AWAR. = problem awareness; ASC. RESP. = ascription of responsibility; ENV. CONC: = environmental concern; ENV. VAL. = environmental values; INT. = intention.
n.s., non-significant.
* $p < 0.1$.
*** $p < 0.01$.
** $p < 0.05$.

Table 5
Effect size analyses of correlates of intention to use non-car.

Variables	K	Sample	$\hat{r}$	Z-value	95% CI		I^2
ATT (car)	4	4204	−0.240	-2.796^{***}	−0.393	−0.073	96.572
ATT (green)	23	17824	0.467	11.086^{***}	0.394	0.534	97.064
INJ. N. (car)	2	391	0.255	1.936^{*}	−0.003	0.481	84.828
INJ. N. (green)	20	16770	0.410	12.819^{***}	0.353	0.464	94.061
DES. N. (green)	7	3272	0.347	5.280^{***}	0.224	0.459	93.095
PER. N. (green)	13	8968	0.508	9.925^{***}	0.421	0.585	95.996
PBC (green)	23	15355	0.526	9.579^{***}	0.434	0.607	98.083
AWAR. CONS.	4	1684	0.236	3.213^{***}	0.094	0.369	89.019
PROB. AWAR.	14	13213	0.315	10.307^{***}	0.258	0.370	91.603
ASC. RESP.	7	2614	0.344	7.014^{***}	0.253	0.429	84.746
ENV. CONC.	14	5518	0.225	7.756^{***}	0.170	0.280	72.609
HABIT (car)	3	3818	−0.096	$-0.180^{n.s.}$	−0.815	0.739	99.817
HABIT (green)	4	1438	0.554	3.454^{***}	0.264	0.752	97.144
Past non-car use	6	3077	0.731	8.891^{***}	0.620	0.813	95.686
ENV. VAL.	9	7547	0.153	4.407^{***}	0.086	0.220	88.016
PERC. USE. (green)	2	671	0.421	11.580^{***}	0.357	0.482	0.000

K = number of outcomes from sample studies; $\hat{r}$ = overall effect size; C.I. = confidence interval; I^2 = I-squared.
ATT = attitudes; INJ. N. = injunctive norms; DES. N. = descriptive norms; PER. N. = personal norms; PBC = perceived behavioral control; AWAR. CONS. = awareness of consequences; PROB. AWAR. = problem awareness; ASC. RESP. = ascription of responsibility; ENV. CONC. = environmental concern; ENV. VAL. = environmental values; PERC. USE. = perceived usefulness.
n.s., non-significant.
** $p < 0.05$.
*** $p < 0.01$.
* $p < 0.1$.

aiming at disrupting old, long-established behavioral patterns as to promote a shift towards innovative and more sustainable routines. According to the Habit Discontinuity Hypothesis (Verplanken & Wood, 2006), when the context changes disrupting our habits a window opens, so that behaviors are more likely to be considered deliberately and alternatives rationally evaluated. As a consequence, "interventions may be more effective when these are delivered in association with a disruption of a stable context" (Verplanken, Walker, Davis, & Jurasek, 2008, page 126): for instance, when we move to a new neighborhood, change job or face other events that modify our travel routines. Such life events evoke conscious reasoning and reorient cognitive gears back to deliberateness, being hence able to weaken car choice habit (Klöckner, 2004) and to induce a behavioral change towards sustainable mobility (Lanzendorf, 2010; Prillwitz, Harms, & Lanzendorf, 2006). There is indeed an emerging stream of literature in transportation research that emphasizes the role of individuals' key life-course events and experiences in leading to change in travel behavior, referred as mobility biographies approach (Lanzendorf, 2003; Scheiner, 2007): such life events can be represented for instance by residential relocation and associated changes in the built environment (Scheiner & Holz-Rau, 2013) but also by acquisition of driver's license, education status change, employment change (Klöckner, 2004; Van der Waerden, Borgers, & Timmermans, 2003) or even first child birth, divorce and retirement (Schoenduwe, Mueller, Peters, & Lanzendorf, 2015).

Indeed, behaviors are the result of a trade-off between deliberate and non-deliberate factors (Van Acker, Van Wee, & Witlox, 2010). The first time an individual adopts a deliberate behavior, as the outcome of a choice between feasible alternatives, he applies a rational thinking moderated by behavioral determinants (e.g., beliefs, perceptions, attitude, social influence etc.). Once the new behavior becomes routine and is repeated over and over in a given situation, deliberate factors don't seem to play their direct role any more: that is, later behavior is largely influenced by past behavior, and is no longer the outcome of a choice between the original alternatives. Consistently with the Theory of Repeated Behavior (Ronis, Yates, & Kirscht, 1989), the joint effect of costs of learning and uncertainties about the impact of a different-from-past decision pushes individuals to "reuse past solutions to make their behavior easier and less risky. This mechanism is enhanced when individuals are constrained by time, budget, or social commitments." (Gärling & Axhausen, 2003, page 2). As long as the given conditions remain stable, behavior would not change and would not necessarily represent the outcome of a deliberate choice between alternatives as it used to be in the beginning. On the other hand, as circumstances change (for instance, change in biographies, new policy interventions, unusual weather change, etc.) the process (might) restart from the beginning: that is, the behavior is once again consciously chosen. Daily commuting represents a typical situation of decisions taken in stable settings: as such, travel behaviors are seldom the outcome of an evaluation-based decision process, while they are highly affected by past behavior and habit.

Also the three planned behavior constructs (attitudes, norms and PBC) proved to have a good predictive capability and, consistently with prior research (Bamberg & Möser, 2007; Gardner & Abraham, 2008), they all appear to be closer to intentions than behaviors. Moreover, while attitudes and PBC seem the main predictors within this framework as regards both intentions and behaviors (Gardner & Abraham, 2008), injunctive-subjective norms emerge as good predictors of behavioral intentions, only. This result contradicts Sheppard, Hartwick, and Warshaw (1988), according to whom subjective norms are indeed a weak predictor of intentions, as well.

All environmental variables directly connected with sustainability issues (environmental values, concern, etc.) seem to play a marginal role as regards the capability of predicting *actual* travel mode choices, while they emerge as significant predictors of *intentions* to choose an eco-friendly alternative. Heath and Gifford (2002) reported similar associations between environmental constructs and behavioral outcomes indicating a mediating role of intention. This is consistent with prior literature (Kennedy, Beckley, McFarlane, & Nadeau, 2009) suggesting that many individuals fail to *walk the talk*: no matter how strong their environmental beliefs and awareness, they will fail to act accordingly to such pro-environmental profile. This is clearly problematic for policy makers and other actors aiming at modifying behavioral patterns of citizens, as initiatives aimed at increasing the awareness and the environmentalism of a community might fail in the end to lead to a concrete, effective behavioral shift. Further insights on the determinants of behavioral intentions and actual behaviors are needed, for instance, to understand which type of instrument (e.g., financial vs. non-financial appeal and inducements) prove to be more effective (Bolderdijk, Steg, Geller, Lehman, & Postmes, 2013; Lanzini & Thøgersen, 2014).

Robustness of results is supported by publication bias analysis,[7] which suggests that in almost all cases such bias is absent: the only exceptions refer to awareness of consequences and ascription of responsibility as correlates of car use (Fail-safe N = 5 and 4, respectively), and injunctive norms towards car use as correlates of intentions to use alternative transport modes (Fail-safe N = 16).

A crucial element to highlight is represented by the great heterogeneity of results, as suggested by the I-squared that in most cases is well above the 75% threshold identifying a large heterogeneity (Higgins et al., 2003). Better understanding of the reasons underpinning such variability is required to set directions for future research as well as for practical decision making purposes (Möser & Bamberg, 2008). We hence identify five study characteristics as potential moderators of the effect size distribution that could explain such heterogeneity, and we perform a moderator analysis, accordingly. The first moderator refers to the operationalization and measurement (MST) of behaviors (and intentions). *Actual behaviors* are measured with reference to a specific time-frame (e.g. "how many times did you drive a car over the past week?"), while *typical behaviors* are measured with no such reference (e.g. "how often do you drive a car?"); we classify measurement and operationalization into typical, actual-days (with reference to a time-frame of a week or less) and actual-weeks (with reference to a time-frame longer than a week). Based on the speculation that the purpose of the trip (TRIP) might affect which predictors assume a prominent role, we adopt a partition where trips have been classified, according to their specific purpose, into *working trips*, *shopping trips*, *general trips* and a residual category *other trips*. The study sample (SAMPLE) moderator is categorized into *general population*, *students*, *employees*, and *others*, as different groups might differ in terms of travel modes. Also geographical location (LOC) of the study (categorized into *Europe*, *North America* and *Far East*) and study period (YEAR) have been included as moderators in the analysis. Since each covariate is required to appear in at least 10 independent studies to be included in the analysis (Borenstein, Hedges, Higgins, & Rothstein, 2009), we combine driving and non-driving intention and behavior datasets as to ensure the inclusion of all covariates in the analysis. To analyze the individual effect of each moderator we used random effects univariate meta-regression with Method of Moments (MM) estimation technique.

Results of heterogeneity analysis are presented in Table 6. Only cases where at least one predictor proved to be significant are reported; however, the complete set of calculations of sub-group and meta-regression analyses can be retrieved from the authors.

[7] For reasons of space only relevant results are presented, but the whole table can be retrieved from the authors.

Table 6
Results of heterogeneity analysis.

		MST	TRIP	LOC	YEAR	SAMPLE
Dependent Variables (ES)	*k*	Q-stats (df) R^2	Q-stats (df) R^2	Q-stats(df) R^2	Q-stats (df) R^2	Q-stats (df) R^2
INT-BEH	22	30.3(2)*** *63%*	9.85(2)*** *14%*	n.s.	15.0(1)*** *34%*	11.2(2)*** *25%*
ATT-BEH	37	9.98(2)*** *23%*	n.s.	n.s.	4.39 (1)** *1%*	22.01(2)*** *27%*
ATT-INT[a]	38	4.69(2)* *27%*	n.s.	n.s.	n.s.	7.87(3)** *27%*
INJ-BEH	28	13.15(2)*** *18%*	n.s.	n.s.	n.s.	n.s.
INJ-INT	29	n.s.	n.s.	n.s.	n.s.	7.96 (3)*** *0%*
DES-BEH	10	16.23(2)*** *50%*	13.2(1)*** *54%*	n.s.	n.s.	n.s.
DES-INT	13	33.0 (2)*** *62%*	4.43(1)** *14%*	n.s.	n.s.	n.s.
PER-BEH	19	n.s.	n.s.	n.s.	n.s.	6.96(2)** *15%*
PBC-BEH	26	7.67 (2)** *20%*	n.s.	n.s.	n.s.	n.s.
PBC-INT	32	6.75(2)** *0%*	n.s.	n.s.	n.s.	n.s.
ENV-BEH	10	7.48(2)*** *40%*	12.6(1)*** *63%*	n.s.	n.s.	N/A
ENV-INT	16	n.s.	n.s.	n.s.	5.62(1)** *15%*	n.s.
PAST-INT	10	10.2(2)** *12%*	n.s.	N/A	n.s.	25.0(3)*** *55%*

Note: Q-stat = chi-square distribution with n − 1 degrees of freedom (df), where n is the number of predictors in the model. It tests whether at least one of the regression coefficients in the model is different from zero; a significant Q-stat confirms the relevance of covariates to the predicted effect size. R^2 = the proportion of true variance explained by the model.
ES = effect size; BEH = behavior; INT = intention; INJ = injunctive-subjective norms; DES = descriptive norms; PER = personal norms; PBC = perceived behavioral control; PAST = past use.
n.s., non-significant.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.
[a] P-value < 0.05 is the decision rule for the significance of the relationships. However, only in two cases, when R^2 is high, 10% significance level is considered.

The analysis shows that measurement is the prominent factor affecting heterogeneity of results: methodological aspects of surveys such as the operationalization and measurement of behaviors and intentions heavily affect the outcome in terms of correlation with relevant predictors. This has evident implications for policy makers. Indeed, since most Travel Demand Management (Eriksson, Garvill, & Nordlund, 2006) and soft transport policy (Möser & Bamberg, 2008) measures have their roots in the informational background provided by analyses of commuters' decision-making processes, it is necessary to better understand the relationship between the operationalization and measurement of constructs and the results of empirical investigations. This will prevent policy makers from shaping strategies based on an over-simplified interpretation of the information at hand.

Also trip purpose and sample type explain heterogeneity of results, though to a lesser extent compared to measurement. As regards sample type, some groups (e.g., students) display specific features that affect their behavioral patterns and the respective predictors, albeit there is evidence that socio-demographics are not effective determinants of pro-environmental behaviors (Diamantopoulos, Schlegelmilch, Sinkovics, & Bohlen, 2003). Consistently with our results, trip purpose has been investigated in literature as a variable shaping modal choice (De Witte, Hollevoet, Dobruszkes, Hubert, & Macharis, 2013). For instance, there is evidence that while car use in prominent for business (Limtanakool, Dijst, & Schwanen, 2006; O'Fallon et al., 2004) or shopping (Kim & Ulfarsson, 2008) trips, alternative modes are more frequents for school (Kim & Ulfarsson, 2008) or short social (Pucher & Renne, 2003) trips.

The low moderating effect of study period is somehow surprising, as it contradicts speculations that over the past 25 years sustainability gained unprecedented relevance in shaping behavioral patterns (Akehurst, Afonso, & Gonçalves, 2012). On the other hand, policy makers can benefit from such stability, as an ever-changing context would represent a hindering factor for the setting up and the implementation of sustainable mobility strategies.

Location is the only mediator analysed that does not explain heterogeneity in effect sizes. This might look surprising, given the differences between the countries where primary studies were performed and the subsequent assumption that both cultural and contextual factors could affect the heterogeneity of results. However, it is worth noting that results are consistent with evidence suggesting that psychological determinants of TPB are generally homogeneous across different regions (Lo, van Breukelen, Peters, & Kok, 2016). With regard to location, one possible speculation that should be addressed by future research is whether other variables might have better explanatory power compared to the country or the macro-region where the studies are performed. For instance, it might be interesting to investigate more in detail the specific features of the area where data are collected: is it a rural or a metropolitan area? Does it have an efficient network of public transportation? Is there an effective involvement of public authorities for the planning and implementation of sustainable mobility plans?

5. Conclusions

Increased car dependency represents a crucial challenge of our times (Blythe, 2005), given the economic, environmental and societal repercussions of private mobility (Schuitema, Steg, & Forward, 2010). Different strategies have been hence proposed to lower the ecological footprint of current travel patterns and to shape new, more sustainable mobility-related behaviors. Given the inconsistent results of literature on transport mode choice and the awareness of the need to gain better understanding of socio-cognitive factors affecting such choice (Cools et al., 2011; Eriksson et al., 2006), we run a meta-analysis to synthesize available evidence, investigating the psychological and behavioral correlates of both private car use and alternative, environment-friendly transport modes. We build on the work of Gardner and Abraham (2008), including recent studies and broadening the analysis encompassing new predictors and perspectives; moreover, we run heterogeneity analysis to explain the variability of results.

Our work has relevant implications especially for policy makers, willing to implement sound mobility plans that require the essential contribution of individual behaviors (De Witte et al., 2013). Some general patterns clearly emerge from the analysis, such as the predominance of intentions, habits and past behavior as predictors of travel mode choice or the intention-behavior gap. However, policy makers should be careful in interpreting such an informational background, avoiding a simplistic and superficial approach that would hinder the effectiveness of policies: for instance, the methodological heterogeneity of primary studies (e.g., the measurement and operationalization of constructs) represents a problematic aspect, as the framing of survey questions has a relevant impact on the outcome on which policy makers are supposed to base their strategies. Whereas a homogenization of methodological frameworks would be particularly complex on a practical standpoint, policy makers or other actors interpreting available information should put extra care in focusing not only on the final results of the analysis, but also on the study characteristics that led to such results.

From the point of view of research, future investigations could first of all increase the number of studies analyzing scantly investigated predictors (that, given the low number of observations, could not be included in our meta-analysis). Moreover, they could as anticipated be more specific in reporting relevant aspects (both contextual and methodological) of the study, specifying for instance the features of both the area and the community where data are collected, as this might represent a factor capable of explaining part of the variability in results. Thirdly, future research should analyze more in detail the effects that some variables exert on (and interacting with) constructs at the base of the theoretical frameworks examined. This is the case, for instance, of so-called residential self-selection and its effects on PBC: indeed, in the domain of mobility self-selection refers to the tendency of people to choose locations based on their travel abilities, needs and preferences (Litman, 2005). The inclusion of a further level of analysis might increase the complexity of the model; yet, such approach could shed further light on the real motives underpinning modal choice, and different methodologies have been proposed in literature to address endogeneity biases (Mokhtarian & Cao, 2008; Winship & Morgan, 1999).

The need to gain further insights on the determinants of modal choices is urgent; albeit the intertwining effect of a wide range of variables (both subjective and contextual) makes the path long and complex, this is no good reason to give up on the task as the reward is well worth the effort.

Appendix A. Search keywords

In the search of relevant literature, we used the following words (plus synonyms and combinations):

Alternative travel modes
Altruistic value
Ascription of responsibility
Attitudes
Awareness of consequences
Bicycle use
Biospheric value
Bus use
Car (use) intention
Car behavior
Car sharing
Car use
Carpooling

Descriptive norms
Driving behavior
Ease of use
Egoistic value
Environmental belief
Environmental concern
Environmental value
General values
Guilt
Habit
Habit strength
Injunctive norms
Mobility
Moral norms
New Ecological Paradigm (and NEP)
Non-car (use) intention
Non-car use
Norm activation
Past behavior
Past use
Peak car use
Perceived behavioral control
Perceived usefulness
Personal car use
Personal norms
Personal values
Private car use
Pro-environmental mobility
Pro-environmental travel behavior
Problem awareness
Public transport
Public transport intention
Reduce car use
Response frequency measure
Self reported habit index (and SRHI)
Self-efficacy
Self-enhancement value
Self-transcendence value
Social norms
Subjective norms
Sustainable mobility
Sustainable travel behavior
Sustainable travel intention
Technology acceptance model (and TAM)
Theory of planned behavior (and TPB)
Theory of reasoned action (and TRA)
Train use
Travel behavior
Travel mode choice
Value belief norm (and VBN)
Value orientation
Walking
Willingness to reduce car

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