Review

Psychological theories of car use: An integrative review and conceptual framework

Samuel Chng a,b, *, Charles Abraham a, Mathew P. White a,c, Christin Hoffmann a, Stephen Skippon d

a Psychology Applied to Health, University of Exeter Medical School, Exeter, EX1 2LU, United Kingdom
b Lee Kuan Yew Centre for Innovative Cities, Singapore University of Technology and Design, Singapore 487372, Singapore
c European Centre for Environment and Human Health, University of Exeter Medical School, Knowledge Spa, Royal Cornwall Hospital, Truro, Cornwall, TR1 3HD, United Kingdom
d Transport Research Laboratory, Crowthorne House, Nine Mile Ride, Wokingham, Berkshire, RG40 3GA, United Kingdom

A B S T R A C T

Personal car use is increasing globally and is an important contributor to poor air quality and global greenhouse gas emissions. Although individuals have little direct control over some emission sources (e.g. heavy industry), they can modify their car use thereby reducing their own contribution. There have been many attempts to understand the psychology of personal car use and identify ways in which individuals might be encouraged to adopt more environmentally friendly travel modes. The aims of this study were (1) to review available psychological theories and models and their applications to understanding car use, (2) to assess the quality of empirical tests of relevant theories and (3) to develop an integrated conceptual overview of potentially modifiable antecedents that could inform future intervention design and further theoretical research. Fifteen psychological theories were identified from thirty-two unique studies but most theories were applied only once. Although two theories in particular (the Comprehensive Action Determination Model and Stage Model of Self-Regulated Behaviour Change) are both relatively comprehensive and have empirical support, our review suggests there are mechanisms of behavioural regulation relevant to car use that are not included in either theory. Integrating theories, we developed an integrative conceptual framework, referred to as the CAr USE (or CAUSE) framework of cognitive and emotional antecedents of car use. This framework is likely to be applicable to other ecologically-relevant behaviour patterns. Implications for research and practice are discussed.

© 2017 Elsevier Ltd. All rights reserved.

Contents

1. Introduction ................................................................. 23
2. Methods ................................................................. 24
  2.1. Literature search ...................................................... 24
  2.2. Article selection ...................................................... 25
    2.2.1. Inclusion criteria for theories .............................. 25
    2.2.2. Inclusion criteria for articles ............................. 25
  2.3. Data extraction ..................................................... 25
  2.4. Quality assessment criteria .................................... 25
  2.5. Inter-rater reliability .............................................. 25
3. Results ................................................................. 26
  3.1. Study characteristics ............................................ 26
    3.1.1. Sample ....................................................... 26

* Corresponding author. 8 Somapah Road, 02-302, Building 3, Singapore University of Technology and Design, Singapore 487372, Singapore.
E-mail address: Samuel_chng@sutd.edu.sg (S. Chng).

https://doi.org/10.1016/j.jenvp.2017.10.009
0272-4944/© 2017 Elsevier Ltd. All rights reserved.
1. Introduction

Transport accounts for approximately 64% of world oil consumption and global transport energy use has doubled in the past 30 years, mainly because of increased car use (International Energy Agency, 2015). Without new regulatory policies, global demand for road travel is likely to double by 2050 with rising numbers of cars in developing countries (International Energy Agency, 2015). This has serious ramifications for human health and the environment (World Health Organisation, 2016). Car use reduces physical activity during commuting (Flint, Cummins, & Sacker, 2014; Wener & Evans, 2007) while substantially increasing carbon dioxide and nitrogen oxide emissions compared to public transport use (Shapiro, Hassett, & Arnold, 2002). In the longer term, affordable low-carbon or carbon-neutral cars may reduce the environmental impact of driving but large increases in car use are predicted before such technologies become widely available (Clark & Cooke, 2016; Falcchio & Levinson, 2015, pp. 53–69). Meanwhile, encouraging more sustainable travel is crucial to mitigating these worrying trends (Garcia-Sierra, van den Bergh, & Miralles-Guasch, 2015).

This will depend on persuading the public, including drivers, to use public transport or walk or cycle, especially for commuting (Van Acker, Goodwin, & Witlox, 2016). While many interventions have been tested there are surprisingly few robust interventions that have been found to reduce car use (Graham-Rowe, Skippon, Gardner, & Abraham, 2011). Research that elucidates the processes by which transport modes are chosen and used routinely is crucial for optimising intervention effectiveness. Models developed within a psychology of transportation can identify antecedents of car use and determinants of behaviour change that may be targeted by interventions (Van Acker, van Wee, & Witlox, 2010). Understanding theorised mechanisms also allows researchers to describe how and why interventions are or are not effective. For example, was an intervention unsuccessful because it had no effect on the targeted mechanism of action or because the targeted mechanism had no or only weak effects on transport behaviour patterns? Robust application and testing of such models or theories in intervention evaluations affords tests of theoretical accuracy and comprehensiveness so facilitating theory development and refinement (Rothman, 2004).

Past reviews in this area have focused on identifying and evaluating specific predictors and change mechanisms underlying car use, without mapping out their relations with other predictors and change mechanisms (Gardner & Abraham, 2008; Klockner, 2013). Such reviews indicate that, while antecedents specified by a range of theories are correlated with car use, many theories do not comprehensively explain car use (because key mechanisms are absent), (e.g., the Theory of Planned Behaviour [Ajzen, 1991] and the Norm Activation Model [Schwartz, 1977]). Thus more comprehensive theories that develop and combine existing theoretical understanding are needed, hence the proposed Comprehensive Action Determination Model (Klockner & Blöbaum, 2010) and the Stage Model of Self-Regulated Behaviour Change (Bamberg, 2013b).

It is also clear that empirical tests of proposed theories do not always comprehensively operationalise the complete range of mechanisms specified by the theory. So it is important to distinguish between complete and partial tests of theories when assessing the extent to which those theories are empirically supported.

This paper reviews psychological theories that have been applied to understanding car use. Theories are a set of concepts and/or statements that specify how phenomena relate to each other, describe a system for what is known, and explain and predict phenomena (Bem & Looren de Jong, 1997; Chalmers, 1976). We had four aims in the current work: 1) identify psychological theories applied to understanding car use, 2) assess the extent to which the identified theories had been applied within the transportation literature, 3) assess the quality of theory utilisation and application within identified studies, and 4) assess the comprehensiveness of theories in terms of their inclusion of relevant mechanisms.

2. Methods

Psychological theories of car use were identified using four sources: electronic databases, web searching, forward and backward searching of reference lists and hand searching of key transport psychology journals. Empirical application of the theories was identified from electronic databases and the reference lists of retrieved articles.

2.1. Literature search

Psychology and transportation databases (EBSCOHost, Web of
Science, Ovid, ProQuest, SCOPUS and TRID) were searched in September 2015, using synonyms for: 1) car use; 2) travel mode choice and 3) theory. The search strategy (see Appendix A) was customised for each database. Sensitivity analysis ensured that key articles on theories relevant to explaining car use (identified in the initial scoping search) were included. The volume of literature meant the search was restricted to titles and abstracts for search specificity. 14,316 unique records were generated for further inspection.

2.2. Article selection

2.2.1. Inclusion criteria for theories

Theories were included if they met our definition of theory and considered individual behaviour as an outcome or part of the process leading to the outcome, which, in our review, is car/non-car use. Theories focusing only on cognition (e.g., intentions and preferences) without application to behaviour were excluded. While such theories may contribute to our understanding of beliefs and intentions, such mechanism may not translate into behaviour (Sheeran, 2002).

2.2.2. Inclusion criteria for articles

A two-stage screening of articles was undertaken. First, examining titles and abstracts, articles were retained if they: (i) mentioned theory in relation to car/non-car use and (ii) were published in full-text format in a peer-reviewed scientific journal. Applying the above criteria, 148 potentially relevant articles were identified.

The second stage (full-text screening) applied tighter inclusion criteria. Articles were included if: (i) the theory used met our study’s operational definition adapted from Michie, West, Campbell, Brown, and Gainforth (2014); a descriptive system of a set of concepts and/or statements specifying how phenomena (car use) relate to each other, describes what is known, and explains and predicts phenomena), and (ii) car use was operationalised and measured. Articles applying multiple theories were included.

Articles were excluded if they: did not include a measure (self-reported or objective) of car use behaviour (e.g., measuring only stated intention or preference for car use were excluded); were not empirical; or did not involve human participants (e.g., computational simulations were excluded). Dissertations and doctoral theses, books, book reviews, conference posters and presentations, editorials and commentaries were excluded to limit the volume of material. We did not exclude articles based on research quality as we were also interested in assessing study’s quality and theory application.

Applying these criteria identified 17 publications. Forward and backward searching of reference lists was also carried out to further identify papers that did not mention using theories in its title and/or abstract until no new citations emerged. This generated 18 further publications. The resulting 35 publications reported 37 relevant studies. Multiple papers reporting the same dataset were regarded as one study so each theory was only extracted once; this excluded 5 studies, leaving 32 independent studies that utilised 15 relevant psychological theories.

2.3. Data extraction

Data was extracted on: (i) theory or theories used, (ii) constructs within the theory or theories that were operationalised and/or tested, (iii) study characteristics (i.e., study’s sample, design and origin, and measures of car/non-car use).

2.4. Quality assessment criteria

Quality assessment of included articles was conducted in two stages using the tool found in Appendix B. First, the study’s quality was assessed using a modified version of the Quality Assessment Tool for Quantitative Studies (QATQS). The original tool, developed by the Effective Public Health Practice Project (Thomas, Ciliska, Dobbins, & Micucci, 2004) for public health research, was expanded to include study designs (prospective, retrospective and cross-sectional) commonly used in transportation research. A study’s quality was assessed on its (i) sample selection bias, (ii) study design, (iii) potential confounders, (iv) blinding (for interventions), (v) data collection methods, (vi) withdrawal and dropouts, and given ratings of strong, moderate or weak. The study’s overall quality was then appraised based on ratings of the above six indicators. Overall quality ratings were given as strong (no weak ratings in any of the six indicators), moderate (one weak rating) or weak (two or more weak ratings).

Further, following the recommendations of the QATQS’s developers we also collected data on two other aspects of study quality: a) Intervention integrity (the degree to which the central intervention could be isolated from other possible co-occurring interventions); and b) Appropriateness of statistical analysis. However the guidelines recommend not including these ratings in the overall final appraisal scores due to potential subjectivity in interpreting these components (Thomas et al., 2004). Hence they are included for background information only.

Next, we developed our own quality appraisal of elements important to the current research but were not in the QATQS, including: a) Theory-informed study design; and b) Theory measurement. Regarding theory-informed design, all studies in the current analysis were informed by theory, by definition. More important here was the extent that the theory was operationalised (e.g., intentions, descriptive norms). We rated those that included 80–100% of constructs as ‘strong’, those that included 40–79% of constructs as ‘moderate’, and those that included <40% of constructs as weak, operationalisation of the theory. For theory measurement, rating criteria included the use of reliable and valid construct measures. Studies demonstrating both validity and reliability were rated ‘strong’, those demonstrating validity but not reliability as ‘moderate’, and those demonstrating neither as ‘weak’, measurements.

2.5. Inter-rater reliability

Articles were screened for relevance first by title and abstract and then by full-text by the lead author (SC). A second researcher (CH) independently screened a random selection of 200 (1.5%) articles at the title and abstract stage and 44 (30%) articles at the full-text stage. Data extraction and quality assessment of studies were initially undertaken by SC with 12 (34.3%) studies independently assessed by CH. Inter-rater reliability was assessed. Differences of views about inclusion and inconsistencies were resolved through discussion and consensus with the other authors.

3. Results

3.1. Study characteristics

An overview of the study characteristics is presented below with more detailed information found in Table A.1. Very high levels of agreement were observed for decisions on inclusion of articles (title and abstract, and full text screening: 100%), data extraction (theory identification: 100%; construct identification: 96% study information: 94%) and quality assessment (overall: 92%; theory application:
94%). Thus further statistical assessment of inter-rater reliability was judged to be redundant. Nonetheless, Gwet’s AC1 scores ranged from 0.91 to 1.00 at all review stages.

3.1.1. Sample

Twenty studies recruited participants from the general population, of which 3 were commuter-only samples (i.e., those who travel from home to work daily), 7 consisted of individuals with car access, 3 with drivers-only samples and 2 samples of individuals who recently relocated. Nine studies sampled students, of which 2 solely included students with driving licence and/or car access. Another 3 studies sampled university employees and one study sampled both university employees and students.

3.1.2. Study design

The 32 studies used very different methodologies. Eight car use reduction intervention evaluations were identified. Only six studies, all intervention evaluations, used experimental designs and were classified as having strong study design methodological quality. For example, see the controlled clinical trial reported by Eriksson, Garrill, and Nordlund (2008) in which individuals were randomly allocated to interventions. Three studies used cohort designs where the same individuals were tested before and after exposure to the intervention or event of interest (e.g., relocation evaluation reported by Bamberg, 2006)) but exposure was not controlled by the researchers. One study used an interrupted time series design with multiple observations over time to compare car and non-car use for daily commuting trips using both self-reported measures and telemetric data. The remaining 22 studies were observational designs (classified as having moderate methodological quality) that were cross-sectional (n = 10), prospective (n = 8) and retrospective (n = 4) in nature.

3.1.3. Measures

Though the initial search included both self-reported or objective measures of car use behaviour, no studies using objective measures were identified. All identified studies used either one or both of the following two types of self-reported car use measures: 1) ‘actual’ car use behaviour during specified time periods reported retrospectively (31 studies), typically using travel diary/log (e.g., Bamberg, 2007), p. 2) ‘typical’ car use behaviour where participants reported their usual car patterns (2 studies). Only one study (Anable, 2005) used both typical and actual car use measures.

3.1.4. Country

The studies, published between 1998 and 2015, were mostly conducted in Europe, specifically 13 (41%) in Germany and 7 in the UK (22%). The remaining 6 (19%) studies were conducted in Asia (3), North America (2) and South America (1).

3.2. Quality assessment

The quality of studies was assessed based on their methodology and theory application. Fourteen (44%) studies were found to methodologically strong, 14 (44%) moderate, and 4 (12%) weak. The assessment of the quality of theory application found 17 (53%) studies of strong quality, 11 (34%) studies of moderate quality and 4 (12%) studies of weak quality. These were based on two aspects of theory application. First, whether the study design was informed by an identified theory and operationalised the theoretical constructs on which 18 (56%) studies had strong ratings while 10 (31%) and 4 (13%) had moderate and weak ratings respectively. Second, whether the theoretical construct measures were reliable and valid on which 28 (88%) studies had strong ratings while 3 (9%) and 1 (3%) studies were given moderate and weak ratings respectively.

Only 9 (28%) studies had both strong methodological and theory application quality. Detailed ratings of each study can be found in Tables A.1 and A.2.

3.3. Theories identified

We identified fifteen psychological theories explaining car use and listed them in Table 1 alongside the theory’s original paper and number of articles here applying it.

3.3.1. Frequency of theory application

By definition, all reviewed studies applied at least one theory. Six (19%) studies applied two or more theories and all included the Theory of Planned Behaviour and/or the Norm Activation Model. Fifteen theories were identified in total, though the following 7 theories accounted for 26 (81%) studies. Half (n = 16) the studies applied the Theory of Planned Behaviour (n = 14) and/or the Norm Activation model (n = 8). A further 5 theories were applied in 15 (47%) studies: Model of determinants of script-based driving choice (n = 3), Value Belief Norm Theory (n = 3), Theory of Interpersonal Behaviour (n = 3), Comprehensive Action Determination Model (n = 2) and Stage Model of Self-Regulated Behavioural Change (n = 2). The remaining 8 theories were applied only once. Appendix C introduces the theories included here.

3.3.2. Theory operationalisation and testing

Eighteen (56%) studies operationalised between 80 and 100% of the constructs within the theory it used (the main theory only if more than one was used) in their study. Ten studies operationalised between 40 and 79% and 4 studies less than 40% of the theoretical constructs. The Theory of Planned Behaviour was the most consistently operationalised as 10 of 13 studies utilising it operationalised between 80 and 100% of its constructs. Most studies (22; 69%) attempted to test the application and fit of the operationalised theory.

3.3.3. Additional constructs identified

Seventeen (50%) studies had also included additional constructs into the theories used. Habit was the most frequently added construct (10; 29%) followed by moral (3; 9%) and descriptive (3; 9%) norms. These constructs were most frequently added to studies using the Theory of Planned Behaviour and Norm Activation Model.

3.3.4. Characteristics of theories

Most identified theories had been described prior to 1998 (the year the earliest paper in this review was published). Four theories were more recent, the Value Belief Norm Theory (1999), the Model of determinants of script-based driving choice (2001), the Comprehensive Action Determination Model (2010) and the Stage Model of Self-Regulated Behavioural Change (2013). The two most recent theories (Comprehensive Action Determination Model and Stage Model of Self-Regulated Behavioural Change) provide more comprehensive models by integrating constructs from well-established theories. Hence we conducted a more detailed review of these two recent theories.

3.3.5. Comprehensive Action Determination Model

The Comprehensive Action Determination Model (CADM) was proposed to understand ecological behaviours by integrating the main assumptions from the Theory of Planned Behaviour, the Norm Activation Model, the Ipsative Theory of Behaviour and ‘habit’ (Klöckner & Blöbaum, 2010; Klöckner, 2013) to incorporate the intentional, normative, situational and habitual influences on ecological behaviours. Fig. 1 shows the findings from all the studies identified by our review support the CADM. Even after removing...
findings from studies conducted by the author theorists (see Figure A1), all the posited relationships continued to be supported by at least one study except for two relationships: 1) person norms to car use habit, and 2) car access to car use behaviour.

3.3.6. Stage Model of Self-Regulated Behavioural Change

The Stage Model of Self-Regulated Behavioural Change (SSBC) was developed to guide systematic intervention development. The theory integrates constructs from the Norm Activation Model as predictors of goal-intention and the Theory of Planned Behaviour as predictors of behavioural-intention into the Model of Action Phases that stresses the deliberative, goal-directed nature of behaviour change (Bamberg, 2013b). By doing so, this new model (a) stresses the self-regulatory nature of behaviour change, (b) conceptualises behaviour change as a transition through temporally ordered sequence of qualitatively different stages and (c) further conceptualizes the intention preceding behaviour into a time-ordered sequence of goal-, behavioural- and implementation-intention.

3.4. An integrative conceptual framework of antecedents of car use (the CAUSE framework)

The CADM and SSBC offer two distinct integrations of concept from well-established theories such as the Theory of Planned Behaviour and Norm Activation Model. The CADM conceptualised car use as a variant of an ecological behaviour and thus incorporated mainly ecologically related antecedents. By contrast, the SSBC conceptualised car use as a self-regulated behaviour and focused on...
explaining its deliberative and goal-directed nature to inform behaviour change. So neither is comprehensive and each could supplement the other. For example, when developing a theory-guided intervention to reduce habitual car use while promoting active and/or public transport use instead, the SSBC would be useful but, because it does not include habitual behaviour, additional constructs and relationships from the CADM could be helpfully added. Nonetheless, these two models overlap and neither comprehensively summarises our knowledge in this area.

Thus, we developed an overview conceptual framework summarising all potential mechanisms of change included in current theories applied to car use. This framework may be useful when designing interventions and tracking the mechanisms through which they are expected to have their effects, for example, when developing a "logic model" (W.K. Kellog Foundation, 2004). Our framework is not a new theory, no new mechanisms are proposed; it is an integration and consolidation of theories already applied to car use. The framework summarises tested mechanisms and highlights those that require further testing. We present this conceptual framework with the strength of evidence supporting each mechanism and proposed relationships between constructs in Fig. 3. Since the framework was derived from studies theorising the causal psychological mechanisms that explain car use, we refer to it as the CAUSE (Car USE) framework.

To create this framework, the CADM and the SSBC were first integrated, mapping out all relationships specified in each and removing duplicates. Car use decisions can be conceptualised as a time-ordered sequential process, thus we adopted the SSBC’s general structure and clustered the constructs within our framework into three stages (cognitive and emotional antecedents, pre-action and action). We included the SSBC’s operationalisation of ‘intention’ to represent the self-regulatory nature of car use decisions within this time-ordered sequence. However, our conceptualisation of motivational transitions differed from the SSBC to account for the additional constructs in our framework. Goal intention was construed as a cognitive antecedent while behavioural intention was recognised to be in transition from being an antecedent of decisions to a preaction construct. Lastly, implementation intention was construed as being in both the preaction and action stages. As the CADM does not operationalise intentions in the same manner as the SSBC, an overall motivational construct was included. This was useful because in some included studies identified motivation as an important construct without specifying between early goal formation and implementation intention formation. We were able to incorporate all constructs from both theories and additional constructs within the framework.

The CAUSE framework presents the constructs and relationships from the CADM within a time-ordered sequential manner proposed by the SSBC and two notable constructs in the framework are ‘habit’ and ‘objective constraints’ from the CADM. First, ‘habit’ was integrated into the category of past behaviour and situated in the preaction stage within the framework to reflect that the car use decision-making process may at times be influenced by past behaviour, an idea supported by the Model of Determinants of Script-Based Driving Choices. Second, ‘objective constraints’ was also situated within the same preaction stage to reflect its relationship with implementation intentions. This reflects that implementation intention in relation to car use (or other travel modes) are influenced by the presence of access to the means to the behaviour, i.e. having access to a car would strongly influence one’s ability to implement an intention to drive. The above manner that ‘habit’ and ‘objective constraints’ were included in the framework meant that we were able to acknowledge the automaticity of car use decision-making and how car access limits one’s ability to carry out their intentions.

The next step in developing the framework involved incorporating findings from the other 13 theories identified in the review that were not already included. This resulted in the addition or expansion of three groups of constructs. First, the category of ‘values’ was added to the framework to acknowledge its role of...
influencing beliefs and norms as postulated by the Value Belief Norm Theory. Four relevant 'values' constructs were identified from Lind, Nordfjærn, Jørgensen, and Rundmo (2015) to be related to the formation and/or maintenance of beliefs and personal norms of car/non-car use and added into the framework: altruistic, biospheric, egoistic and hedonistic values. We also added the related concept of 'environmental concern' was added. This construct, also reported as the New Environmental Paradigm within studies in our review (e.g., Lind et al. (2015)), was frequently measured and has been demonstrated to mediate the relationships between biospheric and egoistic values and personal norm and attitude towards car use. The addition of ‘environmental concern’ and environment-related values highlights that transportation choices may be directed by concerns about environmental conservation (Anable, 2005; Donald, Cooper, & Conchie, 2014; Gardner & Abraham, 2010).

Three normative mechanisms are included. The perception of whether others are engaging in car use (descriptive norm) and whether they approve of car use (subjective norm) as well as whether car use is viewed personally as "right or wrong" (personal norm) are theorised as determinants of intention (Gardner & Abraham, 2010; Mann & Abraham, 2012). Moral norm has been construed as developing from environmental concern and environmental-related attitudes (Donald et al., 2014), but our analyses did not find empirical support for these hypothesised relationships. Moreover, the definition of "moral" and "personal" norms is substantially overlapping across studies (for example, compare Gardner and Abraham (2010) and Anable (2005)). Consequently, we subsumed moral norms under personal norms.

Including the above into the framework at this stage expands its comprehensiveness by incorporating constructs that have been frequently used in transportation research but not necessarily formal components of CADM or SSBC.

Finally, we added the construct 'frequency of past behaviour' that we propose to mediate the feedback loop from behaviour to habit. This was informed by the studies that used the Model of Determinants of Script-Based Driving Choices (Fujii & Gärling, 2003; Gärling, Fujii, & Boe, 2001). This feedback loop represents how each time a car is used/not used may reinforce or weaken the driver's habitual car use and possibly their perception of the ease of using or not using a car in future. There is limited evidence for this proposed relationship (see Fujii and Gärling (2003) and Gardner (2009)) but it may warrant further research.

4. Discussion

Our review identified thirty-two unique studies that applied fifteen different psychological theories to understanding car use. Some theories were more frequently applied than others with seven theories applied in more than 80% of studies and eight theories only applied once. Thus some theories are more influential than others. This is consistent with reviews of theory utilisation across other areas (e.g., Abraham, Sheeran & Johnston 1998; Davis, Campbell, Hildon, Hobbs, & Michie, 2015; Glanz & Bishop, 2010). This is likely due to development and refinement of psychological theory in understanding ecological behaviour more generally. The Theory of Planned Behaviour (TPB) and Norm Activation Model

Fig. 3. Integrative conceptual framework of theoretical constructs of car use (CAUSE Framework).

Note: ††† indicates that this relationship was included in the Comprehensive Action Determination Model. ‡‡‡ indicates that this relationship was included in the Stage Model of Self-Regulated Behaviour Change. †‡‡ indicates additional relationship proposed. * represents that the relationship is proposed but has not tested within any studies identified in the review.

The numerical figures associated with each theorised relationship represent the number of studies within our review that reported support in the following sequence: Correlations (Significant correlations); Path coefficients (Significant path coefficients), e.g., for the theorised relationship from personal norm to intention we identified 1 correlational study that reported a significant relationship and 6 studies reporting path coefficients, of which only 4 studies reported significant findings.
(NAM) were most widely applied before 2010 but, since then, ecological behaviour-specific theories have been developed, in particular the Comprehensive Action Determination Model (CADM) and the Stage Model of Self-Regulated Behaviour Change (SSBC).

Four of five most frequently applied theories (TPB, NAM, Value Belief Norm theory (VBN) and Theory of Interpersonal Behaviour (TIB)) are well established in behavioural science and it is unsurprising that they can partially explain car use. In addition, these theories share constructs and mechanisms. The TPB and the TIB are general theories of social behaviours and include expectance-value and normative belief constructs to explain behavioural intention and behaviour. A key distinction between the two is the extent to which they highlight conscious monitoring of choices versus automatic enactment. The TIB proposes that this conscious control decreases when habitual behaviours are formed and strengthened.

The NAM and VBN were developed to explain specific behaviour patterns. The NAM explains prosocial altruistic behaviour while the VBN explains environmental behaviours but both conceptualise personal norms as its only direct determinant instead of behavioural intention as posited by TPB and TIB. Nevertheless, the theorisation of the mechanisms leading to personal norms differs in both theories.

Given the prevalence of psychological theories have been applied in transport studies for the three decades, it is surprising that there is a dearth of research that systematically evaluates their application. Past reviews and meta-analyses in this area either focused on individual psychological constructs (Gardner & Abraham, 2008) or on a specific theory (Klöckner, 2013), none focusing on reviewing the breadth of theories, implied mechanisms applied or the quality of their application. Further empirical evaluations of the utility of psychological theories and the feasibility of their application in intervention design are needed in relation to car use (and perhaps ecological behaviour, more generally). Nonetheless, this mirrors theory-testing across behavioural science where advances are slow despite numerous calls for greater operationalisation, application, testing and refinement of theory (Abraham, 2008; Davis et al, 2015; Glanz & Bishop, 2010; Michie & Johnston, 2012; Noar & Zimmerman, 2005; Rothman, 2004; Weinstein & Rothman, 2005).

The CADM and SSBC integrated empirically-supported relationships included in existing theories (e.g., personal norm to intention) and added related constructs (e.g., habit). This response to the need for ecological behaviour-oriented psychological theories (Stern, 2000) is an exciting development, not only for understanding car use but ecological behaviours in general. Further testing of such integrative frameworks has the potential to inform intervention and policy design (Truelove, Carrico, Weber, Raimi, & Vandenbergh, 2014). Nonetheless, the need for further empirical studies to establish the validity of the proposed relationships remains, especially the novel time-ordered construal and operationalisation of behavioural intention in the SSBC.

We consolidated findings across identified theories and constructs (e.g., environmental concern) into an integrative conceptual framework of antecedents of car use and we have referred to it as the CAUSE (CAR USE) framework (see Fig. 3). We are not suggesting that this integrative framework should replace existing theories and recognise the challenge of operationalising all the constructs within our framework in any particular study. Its purpose is to provide a map representing how existing theories fit together within our wider understanding of the self-regulation and antecedents of car use and possibly other ecological behaviours, such as recycling or water conversation. This may not be a definitive map of theoretical constructs and may be added to by future research. It does, however, highlight the complexity of mechanisms identified in this area and also the limitations of many of the theories we identified.

The time-ordered sequential self-regulation process in the CAUSE framework provides a useful guide during intervention development to inform designers on which constructs at each specific stage in the car use decision process they should consider targeting. For example, in an environment where car ownership and usage are normative and seen as socially desirable with little awareness of its consequences, goal and behavioural intention to use cars are likely to be strong, so interventionists might consider discouraging action (rather than undermining motivation) by targeting the facilitating conditions of car use such as increasing taxation on car ownership and usage. With a priori knowledge about the mechanisms of behaviour change, targeted interventions could potentially be more financially prudent and effective.

Our integrative conceptual framework is, like all theories and models, a work in progress. The framework was developed from studies theorising causal mechanisms resulting in car use motivation and behaviour. As further tests of CAUSE mechanisms are conducted, some may be highlighted as especially important while others appear less important. Consequently, the framework could be further developed and updated. Some directions for future research into the role of identification are suggested by the construction of the CAUSE framework. First, the framework does not include ‘identity’ constructs, such as ‘green identity’ (Clayton et al., 2015; Whitemarth & O’Neill, 2010). Research establishing the independence and additive predictive validity of such constructs would warrant their inclusion. Second, the cross-cultural validity of environmental research could be improved by the inclusion of collective and individualistic cultural differences in the perception of car use (Cho, Tyroff, Rapert, Park, & Lee, 2013; Greif, 1994; Nayeem, 2012; Oliver & Lee, 2010; Triandis, 1988)). Third, research has explored how global identification using constructs such as ‘cosmopolitan orientation’ (Leung, Koh, & Tam, 2015) representing the extent to which individuals see themselves as part of the global human family, facing global challenges can predict pro-environmental behaviours, such as reduced personal car use. Research could clarify at what level identification has most impact on pro-environmental choices, including choosing not to drive.

Such work could expand the framework beyond individual cognition based on the underlying assumption that we operate as Homo Economicus (rational decision makers, involved in deliberative, mindful decisions, e.g., Ajzen (1991) and Stern (2000)), or predictably irrational individuals (engaging in habitual, automatic behaviours, e.g., Kurz, Gardner, Verplanken, and Abraham (2015) and Verplanken and Orbell (2003)), or a combination of both (Batel, Castro, Devine-Wright, & Howarth, 2016; Clayton et al., 2015) to also clarify how broader cultural and global factors influence the ways in which we think and act.

Most of the studies we identified were European so highlighting the need to raise the profiles of relevant theory to researchers outside of Europe and especially in emerging economies where automotive growth is forecasted to grow rapidly in the coming decades (International Energy Agency, 2015; PricewaterhouseCoopers, 2016). Our integrative conceptual framework will be helpful in these emerging economies for understanding car use antecedents in order to target the appropriate cognitive and emotional antecedents, such as instilling values and cultivating norms, to promote long-term sustainable travel behaviours. Such research could also highlight cross-cultural differences likely to be more important than those observed between European countries (Hofstede, 2001; Nayeem, 2012; Oliver & Lee, 2010).

More than half the identified studies were rated as having moderate to poor methodological quality, primarily due to potential selection bias from low percentages of participation agreement. Participant recruitment in this area seems particularly challenging,
possibly due to the level of burden and disruption to daily life routines that travel studies require (i.e., requiring participants to complete daily travel diaries). Thus, the main challenge for future studies should have lower levels of burden and intrusiveness in daily lives, particularly those using travel diaries and/or travel behaviour modifications. Though the latter suggestion seemingly negates the purpose of behaviour change studies, in reality, commitment and subsequent adherence to behaviour changes is greatly influenced by personal motivation, attitude towards the change and appraisals of its feasibility. Interestingly, studies identified in the review reporting higher percentages of participation agreement (Anable, 2005; Bamberg & Schmidt, 2003; Bamberg, 2006; Eriksson et al., 2008; Mann & Abraham, 2012) may provide useful illustrations of method. Furthermore, with the proliferation of location-based mobile smart technology, future studies can explore the possibility of mobile application-based travel diaries and interventions to further encourage participation (Çolak, Alexander, Alvim, Mehdinratta, & Gonzalez, 2015).

It is also important to highlight that whilst the search strategy aimed to identify most of the relevant studies in this area, it is by no means exhaustive. It was not possible to identify every study that applied a theory to car use because not all studies acknowledged the utilisation of a theory within their title and/or abstract; only 17 of 35 included publications mentioned their use of a theory within their title and/or abstract. Though the search strategy could have been expanded to a full-text, such a search would not have been practical. This emphasizes the importance of reporting theory testing in the abstract and, if possible, within the title.

5. Conclusions

Humanity is causing measurable changes to our ecosystem and only changes in our behaviours at population levels can arrest these trends. The current work attempted to integrate an extensive psychological literature exploring the psychological determinants of car use as an exemplar of how psychological constructs can help us better understand what drives and motivates environmentally-relevant behaviours. Combining 15 theories we developed an integrative conceptual framework of antecedents of car use (the CAUSE framework). We believe this has the potential to clarify which mechanistic relationships are being tested in studies theorising personal car use and so refine our understanding of why people drive and how they can be persuaded to drive less. Thus the CAUSE framework may be helpful to intervention designers conceptualizing new approaches to reducing car use, finally the framework may also be useful to researchers investigating other ecologically-relevant behaviour patterns.

Author’s note

The appendices mentioned in the text and additional supplementary documents are available upon request from the authors.

Conflicts of interest

The authors declare that there is no conflict of interest.

Acknowledgements

The authors would like to thank Prof. Harry Heft and the anonymous reviewers for their valuable comments and suggestions to improve the quality of the paper. This work was undertaken as part of the first author’s PhD funded by a Shell Global Solutions (UK) award to CA and supervised by CA, MW and SS. CA is partially funded by UK National Institute for Health Research (NIHR) Collaboration for Leadership in Applied Health Research and Care of the South West Peninsula Peninsula PenCLAHRC. MW is partially funded by NIHR Health Protection Research Unit in Environmental Change and Health at the London School of Hygiene and Tropical Medicine in partnership with Public Health England, and in collaboration with the University of Exeter, University College London, and the Met Office. The views expressed are those of the authors and not necessarily those of Shell Global Solutions (UK), the NHS or the NIHR, the Department of Health or PHE. The authorship order reflects relative contribution.

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jenvp.2017.10.009.

References

* denotes studies identified in the review.
<table>
<thead>
<tr>
<th>Year</th>
<th>Title</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>From health beliefs to self-regulation: Theoretical advances in the psychology of action control.</td>
<td>Abraham, C., &amp; Michie, S.</td>
</tr>
<tr>
<td>2006</td>
<td>Is a residential relocation a good opportunity to change People’s travel Behavior?</td>
<td>Results from a theory-driven intervention study. Environment and Behavior, 38(6), 820–840.</td>
</tr>
<tr>
<td>2017</td>
<td>Developing a critical agenda to understand pro-environmental actions: Contributions from social representations and social practices theories.</td>
<td>Wiley Interdisciplinary Reviews: Climate Change, 7(5), 727–745.</td>
</tr>
<tr>
<td>1997</td>
<td>Theoretical issues in psychology (1st ed.).</td>
<td>London: SAGE.</td>
</tr>
<tr>
<td>2013b</td>
<td>To be or not to be green: Exploring individualism and collectivism as antecedents of environmental behavior.</td>
<td>Journal of Business Research, 66(8), 1052–1059.</td>
</tr>
<tr>
<td>2005</td>
<td>Successful Ag-</td>
<td>Analyzing cell phone location data for urban travel. Transportation Record: Journal of the Transportation Research Board, 2526, 126–135.</td>
</tr>
<tr>
<td>2015</td>
<td>Analyzing cell phone location data for urban travel.</td>
<td>Transportation Research Record: Journal of the Transportation Research Board, 2526, 126–135.</td>
</tr>
<tr>
<td>1997</td>
<td>The social psychology of material Possessions: To have is to be</td>
<td>Hemel Hempstead, UK: Harvester Wheatsheaf.</td>
</tr>
</tbody>
</table>

S. Chng et al. / Journal of Environmental Psychology 55 (2018) 23–33