



A conceptual analysis of the impact of travel demand management on private car use

Tommy Gärling^{a,*}, Daniel Eek^a, Peter Loukopoulos^{a,b}, Satoshi Fujii^c, Olof Johansson-Stenman^d,
Ryuichi Kitamura^c, Ram Pendyala^e, Bertil Vilhelmson^f

^aDepartment of Psychology, Göteborg University, P.O. Box 500, SE-40530 Göteborg, Sweden

^bDepartment of Psychology, The University of Melbourne, Melbourne, Australia

^cDepartment of Civil Engineering Systems, Kyoto University, Kyoto, Japan

^dDepartment of Economics, Göteborg University, Göteborg, Sweden

^eDepartment of Civil and Environmental Engineering, University of South Florida, Tampa, FL, USA

^fDepartment of Human and Economics Geography, Göteborg University, Göteborg, Sweden

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Abstract

A conceptual framework is presented that may be utilized when analyzing changes in household travel arising from the range of potential measures available to policy makers. The proposed framework draws on goal setting theory in order to understand how travel is influenced by the impact various travel demand management (TDM) measures have on time, cost, and convenience of travel options. Travel is understood from a perspective assuming that it is controlled by negative feedback functioning to minimize deviations from goals nested at different levels. The conceptual framework, with its basis in goal setting and control theories, is then applied to understanding strategic and operational choice related to travel as well as habitual travel. Finally, the proposed conceptual framework is used to highlight and focus attention on key research issues that ought to be addressed if our understanding of the impact of TDM measures on household travel, and private car use in particular, is to improve. © 2002 Published by Elsevier Science Ltd.

Keywords: Travel demand management; Household travel; Car use; Behavioral approach

1. Introduction

Increased environmental and societal costs of private car use such as congestion, noise, air pollution, and depletion of energy are likely future consequences of the worldwide increasing trend in car ownership and use (Goodwin, 1996; Greene and Wegener, 1997; Sperling, 1995). In many metropolitan areas these consequences are in fact already urgent problems that need to be solved. This has resulted in suggestions of a number of policy measures.

The potential efficiency and success of various policy measures for eliminating or reducing traffic problems in metropolitan areas largely depends on how people will respond to them. Lack of public acceptance is an important issue that has been highlighted in recent years (Emmerink et al., 1995; Jakobsson et al., 2000; Jones, 1995). Whether and how travel actually changes is, however, an equally important issue that is far from settled. As has been previously

highlighted by leading travel-behavior researchers (Axhausen and Gärling, 1992; Jones et al., 1983; Gärling et al., 1994; Root and Recker, 1983; Vilhelmson, 1999), it has become increasingly evident that travel results from choices people make that are both interdependent and dependent on desires or obligations to participate in activities. It may therefore be a mistake to focus any measure solely on a target behavior such as car use. In an alternative approach (Gärling et al., 2000, 2002; Kitamura and Fujii, 1998; Pendyala et al., 1997, 1998), travel choice is viewed as an adaptation to changes where people try out different choice options over time.

In this article, we propose a conceptual framework grounded in behavioral theories that may be used to analyze changes in travel due to a wide range of different policy measures designed to influence the travel choices people make. In Section 2, we discuss the possible measures that can be used. We then offer an overview of the conceptual framework in Section 3. Section 4 is devoted to an analysis of behavioral research on goal setting since the conceptual framework identifies individuals' goals and implementation plans as important elements. Section 5 presents a control

* Corresponding author. Tel.: +46-31-773-1881; fax: +46-31-773-4628.

E-mail address: tommy.garling@psy.gu.se (T. Gärling).

Table 1
TDM measures varying from push to pull measures (adapted from Steg and Vlek, 1997)

Taxation of cars and fuel
Closure of city centers for car traffic
Road pricing
Parking control
Decreasing speed limits
Avoiding major new road infrastructure
Teleworking
Land use planning encouraging shorter travel distances
Traffic management reallocating space between modes and vehicles (e.g. bus and high occupancy vehicle lanes)
Park and ride schemes
Improved public transport (e.g. frequency, comfort, retrievability of information about public transport, no price increases)
Improved infrastructure for walking and biking
Public information campaigns about the negative effects of driving
Social modeling where prominent public figures use alternative travel modes

theory of behavior that is a refinement of the conceptual framework. How this theory can be applied to understand travel choice is discussed in Section 6. Section 7 is then devoted to an analysis of the role of habit as an impediment to changing travel. In Section 8, we discuss research directions based on the preceding analyses.

2. Travel demand management measures

There are many conceivable measures that may improve transportation with respect to reduced levels of congestion and air pollution in metropolitan areas. Some of these (e.g. increased capacity of road infrastructure, improved car technology, and limiting speed) do not necessitate a reduction in car use, at least not in the immediate future. A general assessment of the current state is, however, that measures that reduce demand for car use must be implemented in metropolitan areas (Hensher, 1998). In addition, it is desirable to change car use with respect to when and where people drive, particularly at peak hours in city centers. Since the proposed measures focus on changing or reducing demand for car use, we refer to them as travel demand management (TDM). We are aware that this term, coined in the 1970s (Kitamura et al., 1997; Pas, 1995), is frequently not used as broadly as we intend. Other terms with similar meanings include transport system management (Pendyala et al., 1997) and mobility management (Kristensen and Marshall, 1999).

Widely proposed policies for reducing car use include discouraging car owners from driving, making driving less attractive, improving alternative travel modes such as public transport, biking, or walking, and changing the relative locations of homes, work places, and shopping and recreational facilities so that driving distances are reduced. These policies differ in efficiency, cost, technical feasibility, and political feasibility. Vlek and Michon (1992) suggest that

the following categories of TDM measures may be feasible ways of implementing car-use reduction policies (ordered from more to less coercive): *physical changes* such as, for instance, closing out car traffic, providing alternative transportation; *law regulation*; *economic incentives*; *information, education, and prompts*; *socialization and social modeling* targeted at changing social norms; and *institutional and organizational changes* such as, for instance, flexible work hours, telecommuting, or ‘flexplaces’. As they further note, the more coercive strategies may have negative side effects outweighing the expected benefits, whereas the less coercive strategies may be based on untenable assumptions about determinants of car use.

TDM measures may also be classified in terms of those that discourage car use (push measures) and those that encourage the use of alternative modes (pull measures) (Steg and Vlek, 1997). Table 1 presents many examples ordered on a continuum from primarily push to primarily pull measures. It should be noted that the list is not based on behavioral evidence and that the continuum is a heuristic, conceptual guide rather than a precise continuum with clear differences in effects between adjacent TDM measures. Still, there is some empirical evidence, although attitudinal (reflecting perceived effectiveness) rather than behavioral. Stradling et al. (2000) surveyed English motorists providing them with a list of push and pull measures that overlapped substantially but were not identical with those provided by Steg and Vlek (1997). Conducting a factor analysis on participants’ ratings of effectiveness of these measures at reducing their own car use, Stradling et al. (2000) extracted two factors that almost perfectly corresponded with Steg and Vlek’s push–pull distinction. The exception was ‘public information campaigns about negative effects of car use’ which respondents grouped together with other push measures.

We conclude that the different classifications of TDM measures are promising ways of conceptualizing and means of understanding potential reasons for behavioral change (or lack thereof) and, to this end, need to be followed up with in-depth empirical analyses of the behavioral effects. The conceptual framework will be possible to apply in such analyses. A necessary first step is to specify how the TDM measures affect people’s travel options with respect to cost, time, and convenience, then to find out how they react to these changes.

3. Overview of conceptual framework

The general aim is to understand whether and how TDM measures affect private car use. To this end we propose a conceptual framework that will be elaborated on in the following sections. In this section, we present an overview of the conceptual framework with reference to Fig. 1.

We define travel options as bundles of attributes describing trip chains (purposes, departure and arrival times, travel

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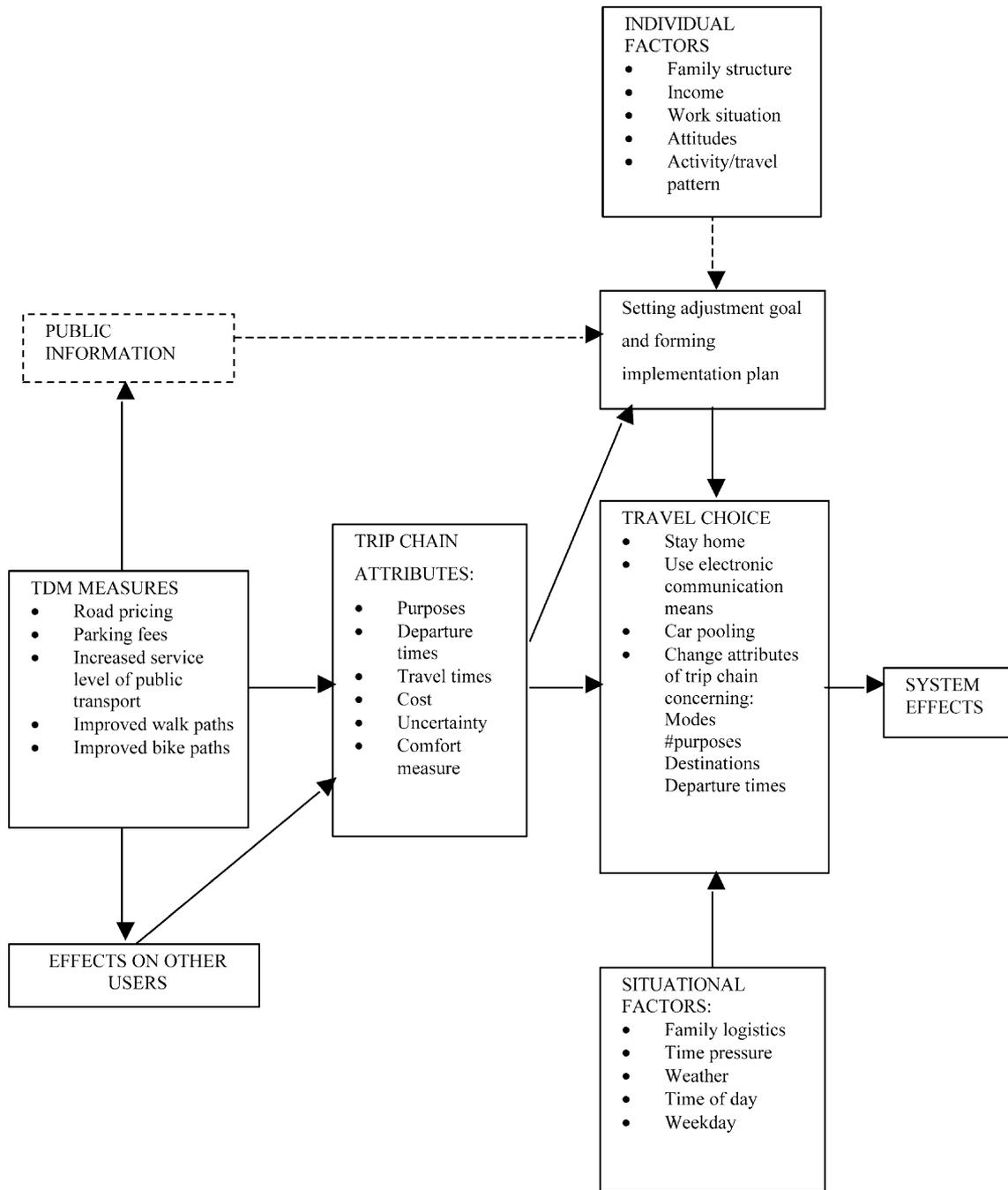


Fig. 1. Proposed conceptual framework.

times, monetary costs, uncertainty, and convenience). It is generally assumed that trip chains rather than trips constitute choice options (Axhausen and Gärling, 1992). Our intuition is that trip chains should be defined subjectively, that is, with respect to what users perceive a trip chain (or travel option) to be. Such a definition reflects the process of forming choice sets (Thill, 1992). Yet, in any empirical study an objective definition must be given. In order to do

this, it is necessary to empirically find principles for how trip chains are conceptualized by users. This is one important research issue that we identify.

A closely related research issue is how to assess the effects of other users of the transportation system who also respond to the TDM measures (Kitamura et al., 1999). This is important since these other users are likely to respond in such a way that the travel options for a target

user are changed over and above the effects that a particular TDM measure (or combination of measures) would otherwise have. A case in point is changes in congestion caused by a wider dispersion of departure times or mode switching. Such an interdependence analysis also needs to include the fact that users sometimes take into account (and are concerned about) choices by other users (Van Lange et al., 2000).

As will be elaborated on in the following sections, we hypothesize that choices of travel options have two classes of determinants: the bundles of attributes characterizing the travel options included in the choice set that households form, and the goals and implementation intentions that households form over time in response to evaluations of monetary costs, time, and convenience of current travel. In addition, choices may be determined more immediately by public information leading to expectations about adverse consequences. These goals may take the form of a specified desired reduction in travel cost and/or car use. Such goals, and the implementation intentions contingent on them, are partly determined by several relatively static factors including income, family structure, work situation, activity/travel pattern, and attitude (e.g. environmental concern).

Implementation intentions consist of a plan for how to achieve the goals given the choice options (Gärling and Rise, 2002). Such a plan in turn consists of sets of pre-determined choices contingent on specified conditions (Hayes-Roth and Hayes-Roth, 1979; Payne et al., 1993). As will be discussed further below, in making plans households may consider a wide range of possibilities such as staying at home, using electronic communications means, car pooling, or changing attributes of trip chains (e.g. modes, departure times) (Gärling et al., 2000). They may also consider longer-term strategic changes such as moving to another residence, selling the car, or changing work place or hours. Choices among these possibilities are likely to be made sequentially over time such that some are tried out and evaluated before others are, starting with less costly and continuing with more costly changes (Gärling et al., 2002).

4. Goal setting

In theories of motivation it is assumed that people have needs (Alderfer, 1969; Maslow, 1954) and desires (Pinder, 1984; Vroom, 1964) that they strive to satisfy. In some theories, needs and desires are thought of as choice outcomes or goals (Locke, 1968; Locke and Latham, 1984, 1990; see also Heath et al., 1999). Goals are assumed to have the two primary attributes content and intensity. Lee et al. (1989) divide goal content into four separate parts: difficulty, specificity, complexity, and conflict. Difficulty refers to the skills required to obtain the goal, specificity to whether or not the goal is quantitative, complexity to the number of different outcome dimensions, and conflict to the

degree to which the achievement of one goal inhibits achievement of another goal. The second primary attribute, intensity, entails commitment, perception of goal importance, and the processes engaged by goal attainment.

Research on goal setting has focused on the relationship between goal difficulty and performance. An important finding is that setting more difficult goals leads to better performance than setting goals that are easier to attain, provided that they are not set too high since then there will be less commitment to the goal and the positive relationship will level off or even become negative. As suggested by Yearta et al. (1995), when individuals have multiple and distal goals, they may choose to invest effort in attaining those goals from which they can expect to obtain more positive outcomes. Therefore, people may choose to work to attain goals with a higher rate of progress so that they experience positive rather than negative affect (Carver and Scheier, 1990). A second finding is that a specified goal leads to better performance than an unspecified ('do-your-best') goal. These findings are robust and have been replicated in many different settings (Lee et al., 1989; Locke et al., 1981).

There are, however, several factors that moderate the effects of goal setting. One such factor is feedback about goal progress. A difficult, specific goal leads to better performance if the person receives feedback about how well he or she is doing. Another facilitating factor is goal commitment. A goal is a motivator only if one is committed to it. The source of the goal (e.g. whether the person participates in setting the goal or the goal is provided) does not seem to be important (Locke et al., 1988).

Goal setting theory (Locke and Latham, 1984, 1990) suggests that an accepted goal directs people's attention and actions toward activities that are relevant to that goal. Furthermore, goals mobilize energy to work towards goal attainment, with the mobilized energy or effort being proportional to goal difficulty. More difficult goals lead to more sustained effort or persistence than more easily attained goals. Direction, effort, and persistence are assumed to be activated almost automatically based on past experience.

In the conceptual framework (Fig. 1), TDM measures are assumed to affect specific trip-chain attributes (e.g. increased travel costs and/or travel times). These attribute changes are proposed to both directly affect people's travel choices, and indirectly through people setting a goal of adjusting to the attribute changes. For instance, if road pricing is introduced, a person will experience increased travel cost. Individual factors, such as income, are assumed to affect whether or not a goal is set to reduce travel costs (i.e. those who can afford to pay the increased travel costs are less likely to set the goal of reducing them than are those who cannot afford the costs). Thus, provided that the increased travel costs are perceived as necessary to reduce, the person will set the goal of reducing them.

In summary, we propose that various TDM measures

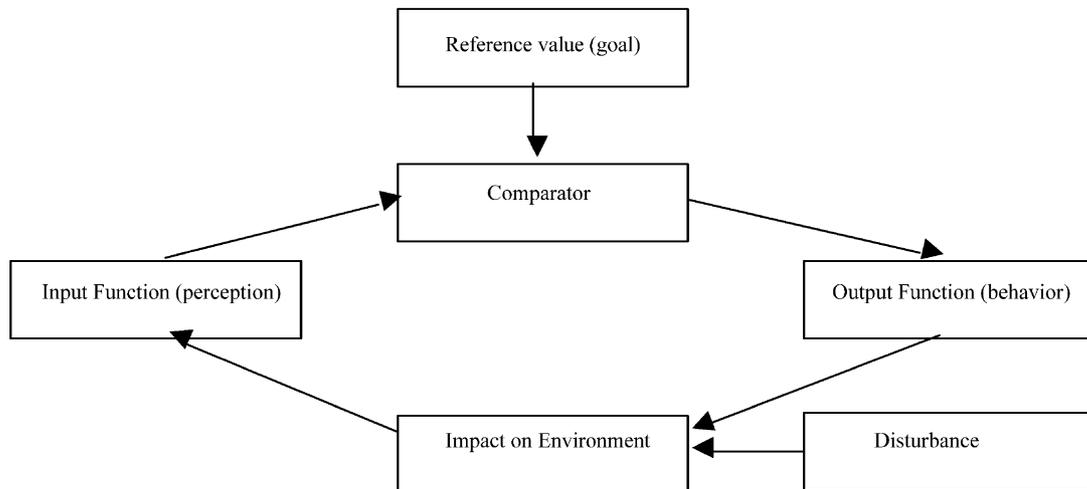


Fig. 2. Goals conceptualized as part of a negative feedback loop.

change trip-chain attributes (e.g. travel costs), which, in turn, encourages setting goals to counter such changes (e.g. to reduce travel costs). The achievement of such goals is influenced by a variety of factors including goal commitment, goal difficulty, goal specificity, and information about progress.

5. Strategic choice

Borrowing from control theory (Ashby, 1956; Clark, 1996; Wiener, 1948), a useful refinement of the conceptual framework is to introduce the concept of negative feedback that minimizes deviations from a goal or reference value. That is, over time people perceive the present situation and compare it to a reference value or goal. If there is a difference between the two, some action is carried out on the environment, thereby minimizing the discrepancy. The model proposed here, shown in Fig. 2, draws on Carver and Scheier (1982, 1998) based on Powers' (1973) theorizing.

Reference values or goals are assumed to be hierarchically organized (Austin and Vancouver, 1996; Carver and Scheier, 1982, 1998). The uppermost level of the hierarchy is termed the system concept by Powers (1973) in that it represents people's ideal image of themselves that they wish to emulate.

The reference value at the next level is that of principle control. Structures at the system concept level provide input in the form of principles for how to act at this level. Yet, these principles are essentially content-free in that they do not specify a detailed plan (Carver and Scheier, 1982, 1998). It is consequently claimed that control at the principle level requires output in the form of programs or plans. The hierarchy of control extends to lower levels. However, since these become progressively more perceptual-motor based, the program level is for our purposes the lowest level in the hierarchy.

To summarize, a control theory of behavior may be particularly useful in understanding changes of travel choice over time in response to TDM measures. It is also consistent with research findings in many areas showing that behavior is frequently controlled by negative feedback. Negative feedback control can be found at the neural (Leibowitz and Alexander, 1998) and motor levels (Ebenholtz, 1986) but is clearly not limited to these lower levels of functioning. Of particular relevance is that control theory has been employed in research on dynamic decision making which requires a decision maker to make a series of real-time, interdependent decisions in an environment that changes both autonomously and as a result of the decision maker's actions (Brehmer, 1990). How successful people are depends on factors, such as negative feedback delay and time pressure, which have been systematically varied or measured in emergency management tasks (Brehmer, 1990, 1992; Brehmer and Allard, 1991; Omodei and Wearing, 1994) or market scenarios (Paich and Sterman, 1993; Sterman, 1989). While it is beyond our present scope to detail the findings of this research, the point to note is that researchers have found that people attempt to reduce the discrepancy between their present state (e.g. a bushfire raging in a certain district or insufficient stock) and a goal state (e.g. an extinguished fire with housing saved or a balance between insufficient and excess stock). In the following we specify how the control theory can be applied to the issue of how TDM measures impact private car use and we give some views of the policy implications of the adopted framework.

Fig. 3 shows possible reference values or goals and subgoals related to car-use reduction. At the system concept level, the uppermost level of the hierarchy representing a person's ideal image of himself or herself, the reference value is one of 'being a good member of society'. People would like to and do tend to see themselves as being concerned about the problems facing the society of which

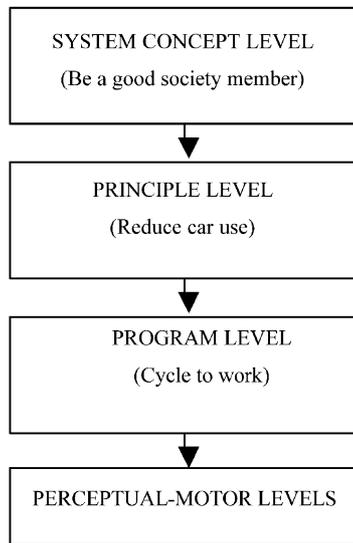


Fig. 3. An application of the control theory model to changes of private car use.

they are part, for example, environmental deterioration or crime. Part of being a good and valued member of society might involve reducing car use because doing so implies that one does not contribute to air pollution and congestion problems. A policy initiative directed at this level could consist of information campaigns or campaigns using role models. These would need to be pull measures as it is difficult to see how a push measure would provide information about an alternative system concept; it would merely inform people of what is not acceptable and this may indeed risk alienating commuters as Stradling et al. (2000) noted.

Reducing car use is a principle-level reference value because it is not a specific behavioral action plan. The next level, the program level, is such a plan and may include cycling to work, taking the bus to work on rainy days, or walking to the local grocery store when only a few items need to be purchased. Policy initiatives leading to the establishment of mobility management centers or travel blending assistance (Rose and Ampt, 2001) could assist commuters to form travel plans (i.e. specific behavioral action plans) where car use is reduced. Of crucial importance to the understanding and prediction of the success, or lack thereof, of various TDM measures is the principle–program connection, discussion of which will be deferred until Section 7.

Programs at the program level are similar to scripts (Schank and Abelson, 1977; Verplanken et al., 1994) in that they consist of a list of actions. However, programs are also general courses of action incorporating decision points where many details are left out (Carver and Scheier, 1982, 1998). The details are not specified since what is done at any given point depends on the circumstances that are encountered. Thus, using the example in Fig. 3, one may cycle to work via a different route if public works are encountered on the way. In the case of driving to the local store, one may stop to refuel if the car is low on petrol. Such

decisions are made in order to match behavior to the goal of reducing car use (Fig. 3). Additionally, Carver and Scheier (1982, 1998) argue that within-program variations such as those described also assist one to conform to other goals (e.g. safety by not cycling through a public works area, or not being stranded by not running out of petrol on the way to the store).

Powers' (1973) and Carver and Scheier's (1982) reference-level hierarchies are steeped in notions of an ideal self and idealized images of oneself. This may not be true of every person and in any case may vary from person to person such that reducing car use may not be the guiding principle. For example, one system concept may be behaving responsibly and the guiding principle to come out of this may be to preserve one's safety (e.g. not traveling alone by public transport at night). This may lead to driving at the program level (in the worst case) or car-pooling. Alternatively, behaving responsibly may entail that one is punctual with respect to work commitments and this, in turn, may lead to one choosing to drive to work.

The way system concepts and principles actually emerge and are formed, and the way they vary from person to person and within persons, is something that needs to be researched more closely.

6. Operational choice

Within the control theory framework specified in Fig. 2, it is argued that the output function or behavioral choice occurs in a manner outlined by Gärling et al. (2002). If people must make changes to their car use that have costs (monetary costs, mental costs, or inconveniences), then they will prefer and actively seek out alternatives that have smaller costs. This has been consistently demonstrated in research on cost-benefit tradeoffs in decision making (Payne et al., 1993). As a consequence of striving to minimize costs (or disutility), the preference is to maintain the status quo in terms of commitments, activities, and travel arrangements. Indeed, one can even speak of a status-quo bias implying that retaining the status quo is not always rational. Kahneman and Tversky (1984) propose that the status quo is the reference level for all attributes and, as such, the disadvantages of alternatives will be evaluated as losses (costs) and the advantages as gains.

If it is not possible to immediately attain the goal, a decision following a lexicographic rule may be implemented. The first step, then, may be to switch modes to public transport or a bicycle or to walk as these leave the activity schedule relatively unaltered. However, for such mode switching to be possible, there needs to be sufficient time between activities allowing one to commute with an alternative slower mode. Even if such time windows exist, the person may no longer be satisfied with the resultant increase in time pressure that he or she is likely to experience (Gärling et al., 1999).

If the above step fails, a further step is to attempt to combine activities or to coordinate activity schedules with others or both. Combining activities so that they are performed at the same time or in sequence at spatially proximate locations is one option. Thus, a person may drive to a location and complete several activities and then return home, having made less car trips than would have otherwise been the case. Coordinating activity schedules with others is an option allowing people to car pool (e.g. going to sporting events together, going shopping or to work together), or allowing one's activities to be carried out at the same time as the activities of others (e.g. a father shopping while his daughter is at the dentist).

If an activity schedule can no longer be maintained or if the travel arrangement is unsatisfactory, then eliminating or substituting activities become potential options. However, not all activities (work is an obvious example) are possible to eliminate or substitute. Leisure activities are perhaps most likely to be removed from the schedule or at least postponed, as may be shopping activities.

The above is a description of a hierarchy of change grounded in the application of key principles that have been identified to characterize human behavior (i.e. status-quo bias, cost-benefit tradeoffs, disutility minimization, and a lexicographic decision rule). However, it is only a suggested, plausible hierarchy of change. To identify the hierarchies that households try is an important research task, as is specifying the criteria that determine these changes.

According to our conceptual framework (Fig. 1), travel choice is influenced through the setting of goals, changes in trip-chain attributes, and the influence of situational factors. TDM measures are assumed to mainly affect travel choice by influencing trip-chain attributes and goals, whereas situational factors influence choices through disturbances (Fig. 2). According to Carver and Scheier (1982, 1998), disturbances can either create deviations from a reference value, which need to be countered, or be sufficiently important so that the reference value changes. Consider a person who has decided to go to work or go out to see a film. Ordinarily, the control system may have ultimately led to the choice of bicycle. If the activities were not planned, then they could also be construed as disturbances (e.g. a friend telephones and asks if you want to go out and see a film). The environment consists of a myriad of disturbances that bombard the person in a largely unpredictable way. So, if it begins to rain heavily, then the system registers another disturbance which (despite having the same reference value) may lead to a different output function: stay at home, choose public transport, or drive rather than walk. For the drive option to occur, the rain must be perceived as a sufficiently strong disturbance so that another grouping of reference values is called up—perhaps safety or comfort. Alternatively, going to work or seeing a film must be valued greatly (or be a sufficient obligation) so that staying at home is not the option chosen.

While it is possible for disturbances to lead to new reference values, it is also possible that the situation is perceived as being novel, never before experienced. Let us return to the previous example concerning the offer to go out with a friend after work to see a film. Assuming this is a novel situation, then some planning needs to be made which involves determining the goals to be attained, the means for attaining those goals and the level at which a decision should be made (there are according to Svenson (1998), four ranging from automatic and habitual to conscious and planned decision making in a new situation where decision alternatives need to be created). In any case, the next step is searching for information concerning alternatives (e.g. travel options). Having obtained the list of decision alternatives, how does one actually make operational decisions related to travel? It is proposed that some decision rule needs to first be applied in order to eliminate non-acceptable alternatives. In this way cognitive effort is saved such that resources may be allocated to the more detailed processing of remaining alternatives. Satisficing (Payne et al., 1993; Simon, 1982) leads to the rejection of decision alternatives with aspects below certain criteria on different attributes. Thus, if one important attribute in our example is convenience, then some alternatives (e.g. walking or cycling) may be eliminated because of the possibility of getting wet in the rain. Other alternatives may not be feasible or applicable to the situation (e.g. car pooling if nobody has a car). In this way, the alternatives are eliminated such that there is only one alternative left or such that a comparison can be made between the two final alternatives (or the most promising two alternatives if more than two alternatives are left).

Disturbances need not be only environmental. They can take the form of family logistics or time pressure (see Fig. 1). An unexpected meeting at work or an after-hours event may cause one to anticipate time pressure that may lead to attempts to change the behavior or may lead to a different set of reference values being adopted. That is, one may first maintain the reduce car-use principle but, if the car must ultimately be used, then he or she may abandon it in favor of the principle of, for example, adhering to one's commitments or getting work done. That is, if the behavior cannot be changed, which will result in a goal-action inconsistency, cognitive change may ensue such that the reference value is changed, thereby eliminating the aforementioned inconsistency (Campion and Lord, 1982; Carver and Scheier, 1982, 1998) and avoiding the motivational conflict of cognitive dissonance (Festinger, 1957). Of course, it may not be the case that such a change in reference value occurs only when the person is incapable of making another choice. The convenience of the car has in itself the potential of acting as an incentive.

How situational factors prevent car-use reduction goals from being implemented is yet another important research issue. Extensive research (for review, see Gärling and Rise (2002)) suggests that goals are frequently not implemented. Gärling et al. (1998) suggest that there are three main

	Behavior	No behavior
Goal	TRUE POSITIVE	FALSE POSITIVE <i>No or unrealistic plan</i> <i>Weak goal commitment</i> <i>Forgetting</i>
No goal	FALSE NEGATIVE <i>Habitual behavior</i> <i>Impulsive behavior</i>	TRUE NEGATIVE

Fig. 4. Four possible relationships between goal and behavior (adapted from Gärling, Gillholm, and Gärling, 1998)

reasons for this. Firstly, when setting goals people are unrealistic because they overlook obstacles to their implementation, in effect believing that they have more control than they actually have. Secondly, people change their minds because they do not have sufficient commitment to the goal. Finally, if a goal cannot be implemented until later, it may be forgotten. As shown in Fig. 4, these reasons may lead to false positives (failure to implement a goal). However, behaviors may also be performed although they are not related to a goal or even in conflict with a goal. Habitual and impulsive behaviors are examples of such false negatives.

Although the theories of planned behavior (Ajzen, 1991) and trying (Bagozzi, 1992) attempt to deal with the question of how goals are implemented, recent work related to attitude theory (reviewed in Gärling et al. (1998)) has focused more directly on the issue. Gollwitzer (1990, 1993) introduced the distinction between goal and implementation intentions. A person with a goal intention has stopped deliberating about alternative goals or end-states since he or she is committed to pursuing one alternative. A choice of implementation route must also be made, consisting of choices of time or sequence and place of instrumental behaviors. When the situational contexts specified by the implementation intention materialize, the intended behavior is triggered by features in the environment activating a memory representation of the goal. Indirect evidence comes from studies demonstrating augmented readiness to perceive relevant situational cues, promotion of attentional strategies for searching such cues, and reduced forgetting of intentions (Gollwitzer et al., 1990; Gollwitzer and Kinney, 1989; Heckhausen and Gollwitzer, 1987).

As similarly argued by Eagly and Chaiken (1993), planning is an important component of the implementation of a goal. A general definition of planning is “the predetermination of a course of action aimed at achieving some goal” (Hayes-Roth and Hayes-Roth, 1979, pp. 275–276). According to Gollwitzer (1990, 1993), planning consists of finding implementational routes to the goal. Consistent with what was stated above, he further postulated that planning ‘ties’ a behavior to a situation. Planning is therefore referred to as

‘mental practicing’ since it is similar to the development of a habit through actual practice. A more general definition may be ‘reduction of uncertainty’ by means of various activities (e.g. information search). This definition was adopted by Gärling and Fujii (2002) in a study showing that commitment to the goal and perceived control were important determinants of planning. Other research (reviewed in Gärling and Rise (2002)) has shown that if participants plan they are much more likely to perform a particular behavior. In fact, the positive effect of setting specific goals (Lee et al., 1989) is probably, to a large extent, the result of the implementation of such goals being easier to plan.

Research reported in Gärling et al. (1997, 1998) demonstrates that planning has a positive effect on actual car-use reduction. In Jakobsson et al. (2002) this effect was even stronger than a substantial increase of the monetary cost of driving. It was also shown that situational factors (e.g. weather, being sick) had an impact on both increases and decreases of car use. An important old insight emerging from this research is that knowledge is a necessary complement to motivation (Locke, 2000). An urgent research question is how such knowledge can be conveyed on a large scale? Public information about the implementation of TDM measures is likely to be more effective if it provides useful knowledge, for instance, about alternative modes and departure times. Likewise, general appeals may only be effective if augmented with information about alternative courses of action.

7. Habits

With repeated occurrence, the principle–program connection (see Fig. 3) may become habitual so that whenever a typical situation arises, the program, which is the output from the principle level of control, is immediately retrieved. An example would be that choosing to drive has become a habitual program (Gärling et al., 2001). This will make the implementation of a new goal (reducing car use) more difficult. A general finding is that intentions and attitudes are not enacted if they are interfered with by habits (Verplanken

and Faess, 1999). That is, they become progressively worse predictors of behavior when habit increases in strength and vice versa. As habit strength increases, depth of predecisional information search decreases (Verplanken et al., 1997). Individuals with a strong habit apparently do not require as much information about the pros and cons of available options. They may, therefore, have false negative beliefs about alternatives (Fujii et al., 2001). All these points suggest that planned, thoughtful decision making is not wholly applicable in these cases.

More specifically, the implication is that drivers, despite entertaining the goal of reducing car use, may not be able to supplant the previous principle–program control of using the car as often as they are accustomed to. In the control theory framework, one possible reason is that the input function (perception of the environment) calls up an entirely different set of reference values in the given situation. Another possibility is that the output function (partly because of habit and partly because of inability to search for alternatives) fails to minimize the difference between the reference value and input function (as gauged by the comparator, see Fig. 2). That is, changing behavior may not be seen as feasible despite the principle encouraging the change in behavior.

Yet, it may not only be an inability to search for information but also an unwillingness to do so that prevents the replacement of an old principle–program connection. Any public information campaigns that attempt to alter behavior by communicating either the advantages or disadvantages of the behavior to be promoted or by referring to norms and values may not be successful. Such strategies work on the assumption that the relevant behavior (i.e. driving a car) is guided by attitudes and intentions (Ajzen, 1991; Ajzen and Fishbein, 1980; Fishbein and Ajzen, 1975). As is argued here and demonstrated in many empirical studies (Verplanken et al., 1998), even if such campaigns successfully alter attitudes and behaviors, these changes may not be reflected in the occurrence of new, different behavior to the extent that the old behavior is habitual (Wright and Egan, 2000).

The relevant question is how a habit can be overruled. Verplanken et al. (1997) provided evidence that this can be done by forcing experimental subjects to pay attention to the decision options or by increasing the functional importance of information acquisition (e.g. being in a new geographical area). However, the effect was temporary with subjects reverting back to their habitual car driving choices. The researchers concluded that consequences of habit can be overruled only temporarily until the habit once again imposes itself on the decision making process. Still, this may not be completely true. Many habits are functional and convenient, and the above experiment did not alter this. The extent to which a habitual behavior is functional can be changed by implementing various policy decisions (e.g. reducing parking spaces). Thus, attitude-based influence attempts may only be useful when habits are broken as a result of such policy measures (Fujii et al., 2001), or, of

course, when new habits are yet to be formed, as is the case when new residential areas are built.

The implications are that the type of information required to break a habit may not be the same information required for the formation of a habit. Furthermore, the suggestion is that the various TDM measures available to policy makers are differentially effective in breaking car-use habits. A research issue is to assess these measures with respect to their effectiveness in this respect, perhaps seeing how differences in effectiveness map on to the push–pull conceptualization present in Table 1. The research reviewed thus far suggests that policy initiatives comprised of push measures would be more effective in breaking a habit but not necessarily in yielding a new behavior. Policy initiatives utilizing TDM measures that fall towards the pull end of Table 1 could potentially do this, but only after the push measures have been successfully implemented.

8. Research directions

To this point we have introduced and discussed the proposed conceptual framework (Fig. 1), elaborating on the various components and processes assumed to function within the framework. Thus, we mentioned the predicted impacts of TDM measures on people and how the measures themselves could be variously classified. The focus then shifted to an analysis of goal setting with some links drawn between TDM measures and the setting of goals. Control theory was applied for understanding of changes in travel choice. It was argued that people have a hierarchically organized set of reference values or goals that they seek to achieve. Finally, habits were discussed within the control theory framework given that much research has indicated the role they play in preventing changes to travel behavior.

Throughout the article, key research issues and areas have been highlighted. These may be summarized as follows:

- How do TDM measures influence attributes of trip chains in terms of cost, time, and convenience?
- Related to the above point is the need to empirically determine the principles by which trip chains are described by people themselves.
- Research into the effects of other users on the transportation system is vital, given the interdependencies present in the system. Users do not operate in a vacuum and their actions affect the actions of others, and the actions of others may affect a target user in ways other than intended by a particular TDM measure.
- Does the content of a goal (i.e. its difficulty or the level of specificity that it possesses) influence the likelihood of its achievement?
- A potentially fruitful research path is to examine and determine the guidelines that influence the emergence and formation of system and principle concepts.

Additionally, the way such concepts vary from person to person and from situation to situation (i.e. within a person) should shed light upon the reasons behind people's travel choice.

- A potential change hierarchy was introduced. However, it is only hypothetical, based on well-established principles that are known to guide behavior. Research is needed to identify the various potential hierarchies of change that households attempt and to specify criteria influencing such changes.
- How situational factors can prevent people from achieving their car-use reduction goals is an important research question. Are there situation types that are more likely to cause this than others? Or are the goals that certain people set in the first place unrealistic? The implication is that knowledge and motivation go hand in hand and, as such, research aimed at determining the most effective means of conveying such knowledge on a large scale is likely to be valuable.
- An important question is if and how car-use habits can be overruled. It has been suggested that attitude-based influence attempts are not likely to be successful on individuals having strong habits. Research into the effectiveness of TDM measures in breaking habits and fostering new behaviors is vital.

9. Conclusions

The aim of the present article was to organize various psychological theories of human behavior in a way that would benefit research into how to change travel-related choices. From this, key future research directions have been identified which will not only improve our understanding of household travel-related choices, but which will also advise society about what are successful means of combating the environmental and social costs of private car use.

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