Sign-dependent Value of Time in Stated Preference: Judgment Bias or Exposure of Genuine Preference?

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Stated choice surveys may be the most common approach to obtain monetary values of travel time. The large surveys of 1988 and 1997 in the Netherlands and of 1994 in the United Kingdom produced some puzzling outcomes, such as differences in monetary valuation between travel time gains and losses. This has given rise to controversies about the behaviour that might have caused this 'sign effect', which are not decisively settled. This paper shows that Prospect Theory and the heuristic judgment concept as developed in behavioural sciences can shed more light on these controversies[2]. It starts with an introduction of some basic principles of these lines of work before re-examining the Dutch and UK surveys from these points of view. It is concluded that the sign effect is not caused by biases that stem from heuristic judgment but follows from loss-aversive valuation of time and money attributes as assumed in Prospect Theory.

Keywords: Stated preference; value of travel time; heuristic judgment; Prospect Theory; loss aversion

1. Introduction

Stated preference (SP) surveys have been conducted in many countries all over the world as an important tool to assess the value of travel time savings (VTTS) (e.g. HCG, 1990; Rizzi and Ortúzar, 2003). Though such surveys may elicit preferences in different ways, e.g. by attractiveness ratings of alternatives or by matching tasks, stated choice surveys are by far the most common. A review of the experimental set-up covers studies in seven countries in which the core of the survey consists of a series of (mostly bi-optional) choice sets with at least two attributes, i.e. trip duration and monetary cost, compared to some reference trip (Burge *et al.*, 2004). The VTTS is defined in agreement with Utility Theory (UT). It is found by estimating the parameters of models in accordance with Random Utility Maximization (RUM) theory that offer the best fit with the SP responses. The outcomes of the national Dutch and UK surveys showed some anomalies from the perspective of RUM theory. One was that increases in travel time were valued higher than decreases of the same size, which Gunn (2001) called the sign effect. This occasioned a controversy about the interpretation of the choice behaviour that explains the sign effect. While Gunn considered it an expression of genuine preferences, several transport

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researchers thought it was caused by biased judgment induced by the artificial nature of the SP setting (e.g. Mackie *et al.*, 2001a). Similar differences in monetary valuation between travel time gains and losses were found in several other SP surveys (e.g. Hess *et al.*, 2008) but the discussion about its meaning for travel behaviour has not been decisively settled.

During the past decades Prospect Theory (PT) has been developed (Kahneman and Tversky, 1979). PT might offer an improved understanding of traveller's choice behaviour (Van de Kaa, 2010a). Heuristic judgment (see next section) plays a crucial role in the valuation of attributes of choice options but may lead to biases (Kahneman, 2002). This paper is aimed to investigate whether the sign effect is caused by biases that stem from the heuristic judgment of time and money attributes in the SP setting or whether they follow from loss-aversive valuation, as assumed in PT. It does not intend to supply improved values for real-life VTTS but proposes tools for doing so in the future. Section 2 summarizes some theoretical notions and background information that seem relevant in this context. Section 3 reviews the experimental designs, analyses and results of the VTTS studies in the UK (1994) and the Netherlands (1988 and 1997) as found in the final reports (AMR, 1999; HCG, 1990; 1998) and elsewhere (Bates, 1999; Gunn, 2001; Mackie *et al.*, 2001a). In Section 4 these are discussed and re-examined from the perspective of heuristic judgment and the basic assumptions of PT, respectively, in connection with a more in-depth analysis of the results of the Dutch surveys. Section 5 summarizes some conclusions.

2. Theoretical background

An SP survey aimed at the assessment of the VTTS presumes that the interviewees value the attributes of the submitted choice options as they would in similar real-world choice contexts, and choose according to the same principles as in everyday life. For the interpretation of the results it is essential to control whether the experimental context might give rise to deviations from their commonplace equivalents. As heuristic judgment may cause such deviations this section describes its principles and some associated biases. Successively, the VTTS concept, as developed within the UT paradigm, is reviewed and defined. Next, relevant basic principles of PT as an alternative choice behaviour theory for UT are listed, as some readers may be unfamiliar with the former, and the VTTS^{PT} concept[3] that follows from them is explained. This section ends with some short notes on decision rules and interpersonal heterogeneity in the use of choice behaviour strategies.

In any choice process people may judge attribute characteristics and values immediately, by reading them from a stored memory (e.g. one's body length) or from current experience (e.g. liking a cake). Other attributes 'are routinely evaluated as part of perception and comprehension, and therefore always accessible' (Kahneman and Frederick, 2002, p. 55). Still other attributes are accessible only if they have been recently evoked or primed. When an attribute is relatively inaccessible it can be substituted by a highly accessible, associatively related heuristic attribute. Kahneman and Frederick (2002, p. 53) formally defined heuristics in this sense: 'judgment is mediated by a heuristic when an individual assesses a specified target attribute of a judgment object by substituting another property of that object – the heuristic attribute – which comes more readily to mind'. Overviews of heuristics can be found in e.g. Gilovich *et al.* (2002) and Van de Kaa (2008).

When Tversky and Kahneman (1974, p. 1131) first introduced heuristics they concluded: 'these heuristics are highly economical and usually effective, but they lead to systematic and predictable errors'. The errors, or biases, are 'reserved for systematic deviations from normative reasoning

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[3] To avoid confusion of the VTTS concept according to the UT paradigm with the very similar concept developed in agreement with PT the latter is denoted as VTTS^{PT} in this article.

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and do not refer to transitory processing errors' (Stanovich and West, 2000, p. 646). In a stated choice setting people may, for example, intuitively value a particular attribute as they are used to doing in everyday life instead of following some 'judge as if' assignment. Such a behaviour is similar to the use of the availability and familiarity heuristics (Tversky and Kahneman, 1974; Metcalfe et al., 1993) and might bias the interpretation of the inferred VTTS.

An important bias that may occur in SP surveys is the anchoring bias, caused by salient but uninformative numbers in questionnaires. Such highly accessible information may replace more appropriate information in the choice subject's memory as the starting point for the valuation of the choice alternatives and attributes. McFadden (2001) reported the occurrence of this bias from an SP survey regarding the willingness of several groups of citizens to pay for annually saving the lives of 50,000 seabirds. The average of the group that answered an 'open-ended' questionnaire was $64, those groups that responded to questionnaires containing numerical cues ranging from $5 to $400 yielded averages from $20 to $143. Mental inertia in connection with the 'fictitious' SP setting might also have caused biases by inciting interviewees to adopt choice rules that they would not consider in a real-life context.

Based on the first principles of Neoclassical Utility Theory several theories of the value of time were developed in the 1960s. The most sophisticated theory (DeSerpa, 1971) considers the value of time as the result of the optimisation of time and money resources under a money income constraint, a time resource constraint (a day counts no more than 24 hours) and minimum time constraints for the consumption of specific goods, like travel. DeSerpa discerns between the value of time 'as a commodity' used for a particular activity, for example a trip to work, and the value of saving time used for that activity. This latter value is what matters in real-life travel behaviour and economic analyses. He defines it as the ratio between the marginal utilities[4] of saving time in a particular activity and the marginal utility of money[5]. In terms of a subject's travel and a particular currency this yields:

VTTS = (Monetary) value of travel time savings (€/h) =

utility of a unit decrease in travel time (-/h) / utility of a unit increase in available money (-/€)

One of the standard assumptions of Neoclassical economics that was implicitly presupposed by DeSerpa (1971) is that the marginal rates of the substitution of goods are the same irrespective of the direction of exchange. This implies that, for a reduction in travel time, the VTTS is the same as the Willingness-to-pay (WTP), which is the unit increase in money expenses that a subject wants to pay for a unit decrease in travel time. It is also equal to the Willingness-to-accept (WTA) a unit increase in available money as compensation for accepting a unit increase in travel time, and to the exchanges of travel time increases for payment increases. For the general conditional indirect utility function that is presupposed in RUM models, Jara-Díaz (e.g. 2002) derived similar findings about the VTTS. He thus demonstrated that his 'subjective value of travel time'[6] is the same as the VTTS according to DeSerpa (1971). An overview of the development of the travel time theories and concepts developed within the UT paradigm can be found in, for example, Mackie et al. (2001b), who used the WTP for a reduction in travel time and the subjective value of travel time of Jara-Díaz and DeSerpa's VTTS indiscriminately. To avoid confusion with the value of travel time as a commodity as discussed by DeSerpa (1971) and others, this article will use VTTS to denote these concepts, including the WTA for an increase in travel time.

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[4] The marginal utility of a good is the additional utility derived from a unit increase in the possession of it.

[5] In agreement with neoclassical UT DeSerpa (1971) and later scientists who studied the value of travel time savings assumed the same marginal utility of available money for all feasible goods/activities including travel.

[6] If a RUM model with linear travel time and cost specification describes observed behaviour well this value is equal to the ratio between the travel time and cost coefficients (Jara-Díaz, 2002).

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The current state-of-practice in the assessment of VTTS from SP surveys is to ask the interviewees to report the characteristics of a concrete trip that they made recently. Based on this reported real-life trip the attributes of a series of choice sets (mostly bi- or tri-optional) are designed by varying the duration and cost of the real-life trip and/or components of these. Often the real-life trip is one of the alternatives in some or even all choice sets. The interviewees are asked to choose the preferred alternative from each choice set of the series. The parameters of a best fitting RUM model with linear-additive utility specification, nowadays often of the Mixed Multinomial Logit type, are estimated. The ratio between the travel time and travel cost coefficients yields the VTTS and/or the value of savings in particular travel time components. One should note that, if the interviewees chose according to the choice behaviour strategy[7] on which the theoretical developments of DeSerpa (1971), Jara-Díaz (2002) and others are built, this yields just one VTTS value that is the same for travel time decreases and increases. Thus, if the assessed VTTS differs significantly depending on whether decreases or increases in travel time are considered their choice behaviour strategy was not in agreement with UT's assumptions.

Kahneman and Tversky (1979, p. 274-284) posited PT against Expected Utility Theory as a set of generic assumptions that 'presents an alternative account of individual decision making under risk'. They defined prospects as alternatives characterized by a probability distribution of outcomes, where the sum of the probabilities is unity. PT assumes that subjects first frame their choice context, particularly by coding the perceived prospects as gains and losses relative to a reference state, rather than considering the expected state of them as presumed in UT. Successively each prospect is valued by applying a value function to the different expected outcomes (or attribute levels), multiplying these with a corresponding weighted probability and adding the products to arrive at an overall expected value, after which the prospect with the highest expected value is chosen. As the decision frame that a subject adopts depends on her personal circumstances and the choice context, including the way choice options are presented and/or perceived, her preference order is thus also context-dependent.

The shape of the value function in the loss domain differs strongly from that in the gain domain. Firstly, PT assumes that people value losses much higher than gains of equivalent size. Tversky and Kahneman characterized this difference with the loss aversion factor[8] λ. It may differ between attributes of the same choice set. Secondly, PT assumes diminishing sensitivity, that is: the marginal value of both gains and losses generally decreases with their magnitude. This implies that the value function is convex for losses and concave for gains. As this paper does not consider the choice between alternatives with a probability distribution of outcomes PT's weighted probability function is not considered here.

PT was originally developed for prospects with mono-attribute outcomes but Kahneman and Tversky (1979) included outcomes with 100% probability under their prospect concept. Thaler (1980) already applied PT – under that designation – to the choice between alternatives with certain outcomes. Kahneman and Tversky (1984, p. 346, 349) proposed that 'in order to evaluate a multi-attribute option … the overall value of an option is given by the balance of its advantages and its disadvantages in relation to a multi-attribute reference state' and defined this overall decision value as 'the contribution of an anticipated outcome to the overall attractiveness or

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[7] An individual's choice behaviour strategy is the combination of the framing, attribute judgment, evaluation and choice rules that she employs in a choice context (Payne *et al.*, 1993; Van de Kaa 2010b). The choice behaviour strategy adopted by DeSerpa (1971) presupposes that each individual considers all feasible alternative activities, attaches the same marginal utilities to increases and decreases in attribute levels, treats all feasible money earnings and money expenses as fungible and chooses the alternative that maximizes her utility within time and money constraints.

[8] The loss aversion factor λ is defined as the ratio between the decision values of a unit decrease in the level of a positively valued attribute of a choice alternative and a unit increase in that level, with $\lambda \geq 1.0$.

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aversiveness of an option in a choice'. They suggested a context-dependent, subjective attribute value assessment by intuitive processes in which the hedonic appraisals of former activities may play a decisive role, although a trade-off between the decision values of all feasible alternative time and money spendings seems unlikely. For the decision value of money they adopted 'mental accounting' as proposed by Thaler (1980), which implies that the decision value of money may differ between activities and contexts. Later, Tversky and Kahneman (1991) elaborated the applicability of PT to choice contexts with 'certain' two-attribute outcomes, without extending its constituent assumptions, as a reference-dependent model[9]. As the trip alternatives that were submitted to the interviewees in the Dutch and UK SP surveys were characterized by two attributes, travel time and travel cost, this paper follows their 1991 elaboration of PT closely.

In this article the $VTTS^{PT}$ in agreement with PT is defined analogous to DeSerpa (1971). That the decision value of money may differ between activities is taken into account. It also considers that different people may treat travel cost increases either loss aversively or loss neutrally (see e.g. Kahneman and Tversky 1984). This implies that the $VTTS^{PT}$ is defined as:

$VTTS^{PT}$ = (Monetary) value of travel time savings (€/h) =

(Decision) value of a unit decrease in travel time (-/h) /

(Decision) value of a unit decrease in monetary travel expenses (-/€)

In connection with different loss aversion factors for time and money this yields:

WTP for a reduction in travel time $\qquad\qquad\qquad\qquad\qquad$ *= $VTTS^{PT} / \lambda_{cost}$*

WTA for an increase in travel time $\qquad\qquad\qquad\qquad\qquad$ *= $VTTS^{PT} * \lambda_{time}$*

Ratio of the value of a unit increase in travel time to that in cost $\quad$ *= $\lambda_{time} * VTTS^{PT} / \lambda_{cost}$*

PT suggests a compensatory decision rule to wind up the choice process (Kahneman and Tversky, 1979, 1984). Compensatory rules compound overall values for each alternative and compare these. The weighted linear additive value rule is the most commonly accepted one in both UT and PT. It presumes that the choice subjects add up the values that they assigned to the different attributes of alternatives, after multiplication of each value with a corresponding subjective attribute decision weight (Payne *et al.*, 1993). For most VTTS surveys the interviewees are supposed to assign a monetary value to travel time variations and thus include the subjective attribute decision weight in their VTTS judgment. One should note that if either travel time or travel expenses are valued much higher than the other attribute, the so-called non-compensatory strong lexicographic rule becomes descriptively indiscernible from a linear additive value rule.

Non-compensatory rules compare the alternatives attribute-wise. Presumably the most common non-compensatory strategy in consumer behaviour is a two-stage process where an aspect-based elimination rule is followed by a compensatory rule (e.g. Cantillo and Ortúzar, 2005). In decision theory, many compensatory and non-compensatory decision rules are reported that people may use (overviews e.g. in Van de Kaa, 2008; 2010b). For the analysis of choice processes that follow the principles of PT it is assumed here that during successive choices in the same domain-context combination most people consistently use just one of the choice behaviour strategies from their 'toolbox' (Payne *et al.*, 1993). This may be considered as a weak substitute for the concept of the complete, transitive and context-independent idiosyncratic preference order of UT.

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[9] Since then, such applications might be encountered under the name of PT (e.g. List, 2004) and/or Reference-dependent theory (e.g. De Borger and Fosgerau, 2008).

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3. A review of the Dutch and UK national VTTS surveys

Between 1988 and 1997 three large-scale SP surveys to assess the VTTS were performed, two in the Netherlands and one in the UK. The experimental design of the three surveys was remarkably similar. The final report of the oldest Dutch study (HCG, 1990) contains a description of the experimental design, including examples of the questionnaires employed. For the Dutch 1997 study the 1988-design was replicated almost exactly (HCG, 1998).

The researchers did not aspire to surveying a representative sample of the population. The survey panel members were recruited while they were 'on their way' for business, commuting or other purposes. They were asked on the spot to answer questions about their actual trip (including origin-destination, motive, expected travel time). If they were willing to participate in a postal survey they were sent a questionnaire. The first section of the questionnaires asked evaluative information about the previous trip (e.g. refund of costs, delays, arrival time). The final section comprised questions concerning personal and household characteristics like gender, age, employment and income. In between was the SP game that contained twelve bi-optional choice sets with time-cost trade-off SP questions. The submitted alternatives were retrospective, using the actual trip the respondent was undertaking at the time of the recruitment interview as a reference. Four choice sets contained the reference trip and either a time loss/money gain or time gain/money loss alternative; one set contained a dominant alternative, added to check for the interviewees' understanding of the questionnaire. There were different questionnaires for four reference trip duration classes. Table 1 shows the nominal values of the submitted monetary and time losses and gains. These were the same in both surveys.

The 1994 British study essentially followed the same experimental design as the Dutch surveys (AMR, 1999). Public transport passengers were not surveyed. The reference trip duration bands were smaller than in the Dutch surveys and the submitted trip duration and cost variations differed accordingly. 11 Distinct sets of choice sets were submitted. Each questionnaire contained eight different bi-optional comparisons. Four of these compared the reference trip with either a time gain/cost loss or time loss/cost gain alternative. In the other four comparisons the difference in either the cost or the time from the reference trip was set at zero in all eight alternatives; here either a time gain was traded against a monetary gain, or a time loss against a monetary loss (Bates, 1999).

Table 1. Submitted trip duration and cost variations, Dutch VTTS studies

Reference trip duration (minutes)	Trip duration variations (minutes)	Trip cost variations (guilders,- means increase, + decrease)	
< 45	-10; -5; 0; 5; 10	11 values	from -3.0 to +1.5
46-90	-10; -20; 0; 10; 20	11 values	from -6.0 to +3.0
91-135	-15; -30; 0; 15; 30	11 values	from -9.0 to +4.5
>135	-20; -40; 0; 20; 40	11 values	from -12.0 to +6.0
Source: final reports of the Dutch VTTS- surveys (HCG, 1990; 1998)			

All the analyses of these surveys that have been reported to date have presumed that the choice behaviour of the interviewees complied with the premises of UT; see e.g. AMR (1999, p. 5). Logit models were used for the analyses. The utility of each option was calculated based on the cost and time differences with respect to the reference trip, with household income, journey purpose etc. as explanatory variables. The Dutch studies attributed the same weight to increases and reductions in cost and time relative to the reference option. The models used in the UK survey discerned increases and decreases of time and cost with respect to the reference as well. This

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resulted in a much better model fit than that for a simple model using only time and cost as variables (AMR, 1999, p. 162).

The first Dutch SP survey found greatly differing values for the average VTTS depending on trip motive and travel mode (HCG, 1990, p. 23). Inflated to the 2005 price level and converted to € the range was between €5.2/h for 'other' purposes and €12.7/h for business, and from €4.4/h for bus and tram passengers to €9.4/h for car drivers. Though the survey panel was not a representative sample of the Dutch population the findings are obviously indicative of roughly corresponding real-life differences. Some more significant relationships: for all purposes and travel modes VTTS increased systematically with income and with a decrease in personal 'free time'; and the VTTS of young commuters and business travellers was much higher than average while that of elderly people was below average. As far as corresponding figures could be retrieved from revealed preference surveys these confirmed this pattern and were of the same order-of-magnitude. The second Dutch survey (HCG, 1998) and the UK study (AMR, 1999) found a similar variation in VTTS, dependent on trip purpose, income, age group and travel mode (Dutch survey only).

The final report of the Dutch 1988 study mentions: 'there was strong evidence that travellers value time savings at a much lower rate than time losses. For commuters, in particular, losses were valued around 50% higher than average, and savings around 50% lower' (HCG, 1990, p. 21). So far, the only additional quantitative information on this aspect was published in Gunn (2001, p. 181). Similar results from the UK survey are tabulated in AMR (1999, p. 181), preceded by a thorough description of the model used for the analysis.

The available data were inflated, adapted to present-day currency and are presented in Figure 1. This demonstrates the difference in the valuation of gains and losses: 'Our results … confirm that time losses are valued, per unit, significantly higher than time savings' (AMR, 1999, p. 29). It also shows that the VTTS for large time changes is higher than for small ones. Averaging the outcomes of different trip duration classes might have suggested the high loss aversion ratio ($\lambda_{time} \approx 3.0$) that HCG found for Dutch commuters in 1988, see citation above.
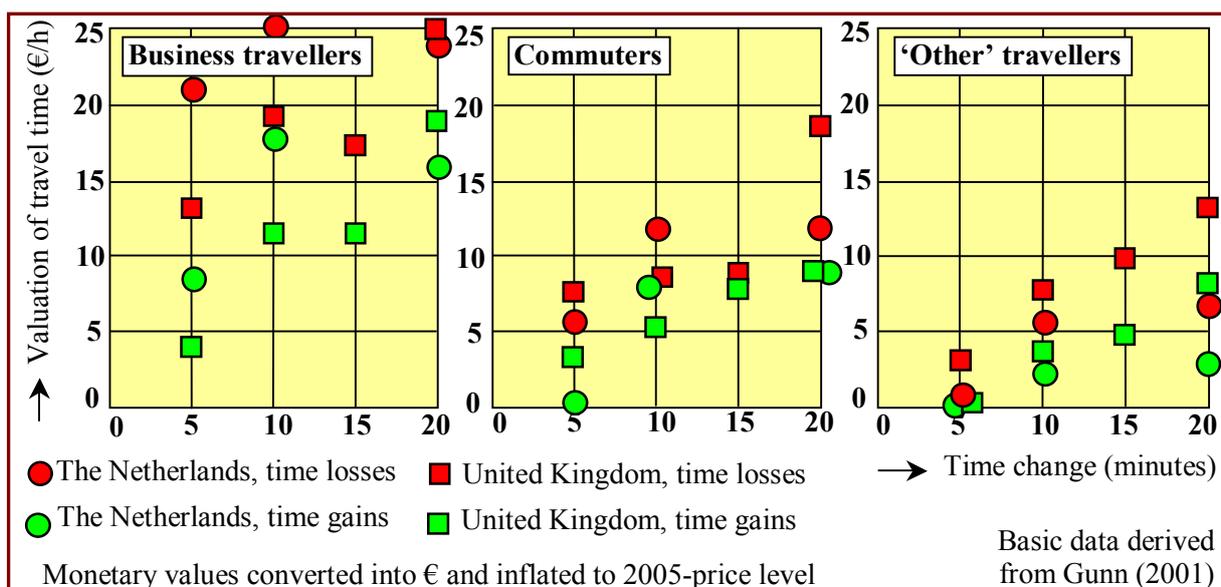
Figure 1. Sign and size dependency of the VTTS

Bates (1999) re-analysed the data of the UK study as reported in AMR (1999) on size and sign effects averaged over all trip purposes. Later on, his analyses were refined, differentiating

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between business trips, commuting and other travel purposes (Mackie *et al.*, 2001a). Both studies mapped the choice sets of the SP game on a coordinate system with the reference trip as origin and the time and monetary cost increases on the horizontal and vertical axis, respectively. Figure 2 illustrates this concept after transformation into an indifference map as common in Neoclassical UT, with discretionary disposable money, or time, for 'other' purposes on the vertical and horizontal axis, respectively. From this it is clear that Bates (1999) and Mackie *et al.* (2001a) presumed a strict independence of both the size of duration and the cost of the reference trip and the size of the evaluated cost and time changes. Furthermore they assumed random interpersonal variations in attribute valuation between the interviewees who were presumed to value trip duration and money expenses according to UT.

Bates (1999) had only the percentages of the respondents that chose the first or second option from each of the UK choice sets at his disposal. Treating these percentages as expected choice probabilities he calculated the logit values for each of these 88 choice sets. He also plotted these logit values against the 'boundary values of time', that are the values of time for which both alternatives should be equally attractive. From this plot Bates concluded that the VTTS was very high in quadrant 2, very low in quadrant 4 and broadly similar in quadrants 1 and 3. However, a rough estimate of the 'average' VTTS in each quadrant may be found at the intersection of the regression curve through the concerned logit values and the 'boundary value' axis. A secondary analysis using a linear regression showed that the VTTS in quadrant 3 was more than twice the value in quadrant 1.
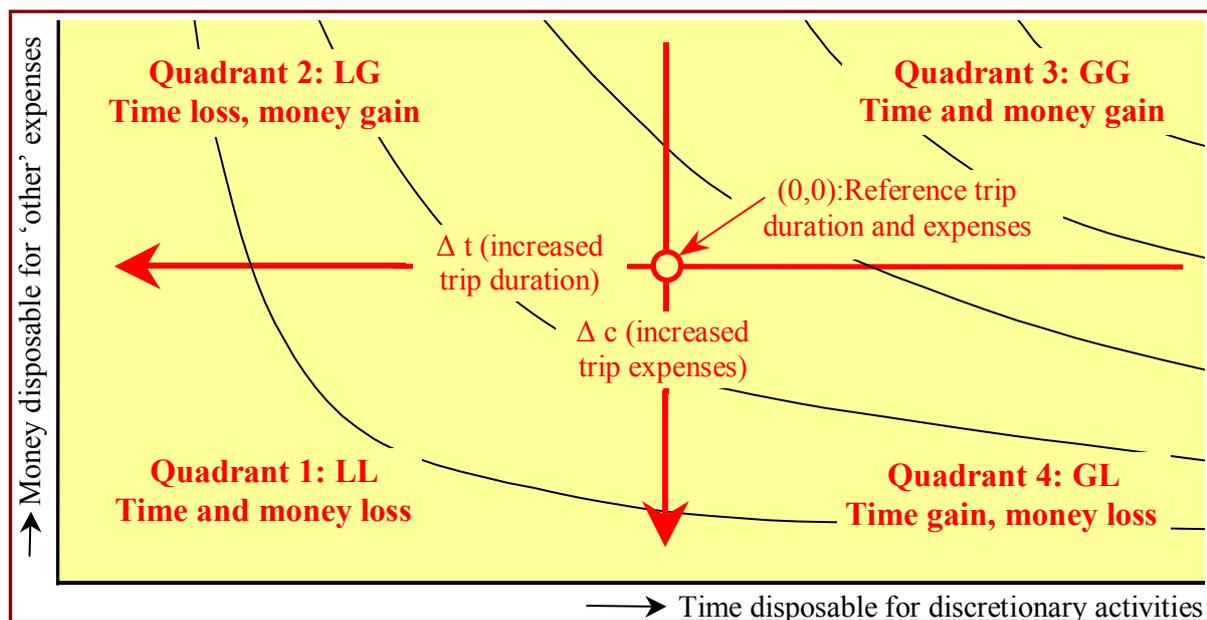
Figure 2. Time-money indifference map and trip costs

Using standard linear regression Bates also estimated the cost and travel time parameters of a simple binomial logit model with linear utility specification that offered the best fit with the 88 calculated logit values. Mackie *et al.* (2001a) estimated a similar model for the disaggregate responses, after splitting them up according to quadrant and trip purpose. The different VTTS values[10] are listed in Table 2. The findings from the different models reflect the same dependency. Averaging the VTTS in quadrant 1 and 2 (time losses) and 3 and 4 (time gains) yields the same orders-of-magnitude as the mean values in Figure 1.

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[10] These and all other monetary values from the 1994 UK survey are inflated and converted to € in this article.

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Table 2. Sign dependent VTTS from responses to the UK 1994 Stated Choice survey

Average VTTS in €/h in quadrant	1	2	3	4
Based on Bates (1999), estimates from aggregated choice frequencies of 88 choice sets, all trip purposes				
From secondary analysis of logit values plot (p.323)	4.7	15.8	9.4	-1.7
From estimated cost and travel time parameters (p.308)	5.9	15.8	8.7	-0.1
Based on Mackie *et al.* (2001a), from estimated cost and travel time parameters in binary logit models				
VTTS per quadrant for business trips	10.4	25.1	13.4	5.5
VTTS per quadrant for commuting	5.3	13.3	4.3	1.7
VTTS per quadrant for other trips	5.2	12.9	3.8	1.5
Aggregated responses to UK survey, VTTS inflated, rounded off and converted to 2005 price level in €/h				

Mackie *et al.* (2001a) showed that the differences in the VTTS between quadrants 2 and 4 disappeared when an inertia term was introduced in the models. This persuaded the authors to conclude that 'there is no justification for valuing time gains at different unit rates from time losses' (Mackie *et al.*, 2001a, Conclusions). Thus they rejected the conclusion of AMR (1999, p. 9) that 'for any level of variation around the original journey time, gains (savings) are valued less than losses'. Using these models including inertia terms Mackie *et al.* (2001a, Sect. 2.2) found 'that the unit values of small time savings come out very different from large' but concluded 'Our feeling is that the lower values for the small time changes arise because of the artificial nature of SP exercises'.

4. The sign effect re-examined from the perspectives of heuristic judgment and Prospect Theory

Based on the theoretical concepts presented in Section 2, the information contained in the reports of the Dutch and UK studies and in the articles of Bates (1999), Gunn (2001) and Mackie *et al.* (2001a) was re-examined for the conceivable occurrence of biases induced by the experimental design and for the likelihood of sign-dependency of VTTS. The RWS Centre for Transport and Navigation also made the full documentation of both Dutch surveys available, including the tabulated responses of the individual interviewees. These were excellently filed away and saved by HCG's successor, Significance. Some findings from these data are presented here as well. To facilitate the comparison with the UK survey the responses of Dutch public transport users are disregarded here.

4.1 Hedonic framing of the questionnaire

Several aspects of the experimental designs are well in line with premises from PT. The 'reference state' was clearly circumscribed in the questionnaire and embedded in a recently experienced real-life trip taken by the survey subjects. In case this was a trip during working hours and/or paid for by the employer participants were explicitly instructed to consider these as made in their own discretionary time and at their own expense. This, combined with the general propensity of interviewees to take the wording of questionnaires for granted (Kahneman, 2002, p. 458) leaves little doubt that most people framed trip time and cost reductions as gains and increases as losses.

However, as Thaler (1999) mentioned, people are inclined to frame the outcomes of alternatives in such a way that they promote their interests or happiness as much as possible. People whose travel expenses are reimbursed might apply this 'hedonic framing' principle by treating all cost

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changes as loss-neutral, or might even value any cost changes as negligible. One might observe that such behaviour would be consistent with premises of both PT and UT because the changes in trip expenditures would not alter the money available for 'other' expenses. The 'rational' decision weight for the cost attribute should therefore be zero. Another way to arrive at the same choice behaviour is related to the availability and/or cue familiarity heuristic (Tversky and Kahneman, 1974; Metcalfe *et al*., 1993): when answering the SP game, reimbursed travellers may unconsciously appraise the alternatives as they are used to do in everyday life and forget that they were committed to replying 'as if' the trip costs were not compensated. Both hedonic framing and application of this judgment heuristic would result in the same choice behaviour as caused by the application of a strong lexicographic decision rule, here by selecting the alternative with the lowest trip time from any choice set.

In the Dutch survey from 1997, 49% of the car drivers stated that the reference trip costs were completely compensated. The individual responses to the choice sets showed that about 14% systematically chose the alternative with the lowest travel time, quite comparable to the percentages reported from three-attribute experiments in Chile (Rizzi and Ortúzar, 2003). This percentage rose to 19% for people whose expenses were reimbursed. Two-thirds of these 'strong lexicographic' choosers got their reference trip expenses reimbursed while only 14% of them got no compensation; the remaining interviewees got a partial reimbursement. Complete reimbursement applied to most business travellers (72%) and many commuters (41%) but to only 19% of the 'other' travellers. In view of the distribution of reimbursement over the different trip purposes the associated difference in the frequency of lexicographic answers might partly explain the trip purpose dependency of VTTS as observed in the UK and Dutch surveys. Both for completely reimbursed and not-reimbursed trips the percentage of business travellers that systematically chose the alternative with the lowest travel time (23% and 17%) was well above that for commuters (18% and 9%) and other travellers (14% and 4%). This bias, therefore, definitely does not annihilate the purpose dependency of the VTTS. Closer examination of the Dutch results showed that the percentage of interviewees who systematically chose the fastest alternative varied strongly with income. Taking into account this distribution over reimbursement category, trip purpose and income class, this bias might cause an overestimation of lexicographic answering by about 1.5% of the survey population, which might have inflated the average VTTS by a few percent.

The preference order found from lexicographic answering does not depend on differences in appraisals of gains and losses. This bias does therefore not contribute to the sign effect. Two choice sets the UK and Dutch SP games compared the 'no change' alternative with a travel time gain and two others compared is with an increase. This bias might thus have underestimated the number of respondents who systematically choose the 'status quo' alternatives.

In the Dutch surveys, hedonic framing and/or the employment of judgment rules related to the availability and cue familiarity heuristics might have biased the VTTS of travellers who received reimbursement for their trip. It may have overestimated the VTTS with a few percent at most. In future surveys one might arrange for a sample with sufficient numbers of reimbursed and not-reimbursed travellers in the relevant trip categories to control for such a bias in the VTTS.

4.2 The anchoring bias

Dutch travellers are hardly ever confronted with operational time-money trade-off decisions. Thus many interviewees may have found it difficult to map values of time on a monetary scale, even when they were well aware of the context-dependent individual decision value that they attribute to travel time gains and losses. This may imply that an anchoring-and-adjustment heuristic was used to arrive at a judgment of the monetary value.

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The introduction to the SP game in the Dutch 1988 survey contained an example of the choice sets with instructions for completion. Some of the interviewees might have used the boundary VTTS in this example as the 'anchor' for an adjustment of the valuation in the appropriate direction. However, such 'adjustments tend to be insufficient, leaving people's final estimates biased towards the initial anchor value' (Epley and Gilovich, 2002, p. 139; see also the findings of McFadden referred to in Section 2). For the 1988 survey this anchor was €3.8/h, almost the same as the VTTS found from revealed preference analyses for 'other' trip purposes and well below the VTTS revealed from real-life commuting and business trips. An anchoring bias would thus imply that the VTTS values of business travellers and, to a lesser extent, commuters as found in the 1988 SP survey should be well below those found from revealed preference surveys. The average revealed preference data reported in HCG (1990) show this pattern indeed but as the SP values are within the 95% confidence interval of the revealed data this comparison does not offer solid proof for the occurrence of an anchoring bias.

The cost attributes in the example and the 12 choice sets submitted in the 1997 Dutch survey had the same nominal values in guilders as in the 1988 survey. Meanwhile the consumer price index of the Dutch households rose by 25% and their purchasing power improved by 7%[11]. One would thus expect that the nominal VTTS would increase by at least 25%. Gunn (2001) found that the 1997 VTTS lagged 6.5% (business), 10.3% (commuting) and 9.5% (other) behind inflation. After expansion of the survey results to the Dutch population and correction for inflation HCG (1998) found changes in VTTS levels that differed strongly depending on the considered segmentations. They reported an average increase of 33% for the employees' VTTS for business trips, a 5% increase for commuting and a 9% decrease for other trip purposes. An anchoring bias would imply that the increase over time of the VTTS is smaller for business travellers and, to a lesser extent, for commuters than for other travellers. Thus neither the results of Gunn (2001) nor these of HCG (1998) can be explained by such a bias.

In sum, though the Dutch SP questionnaires provided a highly accessible anchor no solid evidence was found that the answers were affected by an anchoring bias.

4.3 The inertia bias

When people stick to their earlier behaviour social scientists often denote and/or explain this as (mental) inertia. Except for common language definitions like 'disinclination to act or exert oneself' (Shorter Oxford English Dictionary) no covering definition was found for the different concepts used by social sciences. The real-life examples of inertia that Thaler and Sunstein (2009) put on the stage include, for example, the disregarding or omitting of choice opportunities, postponing or abandoning of intended choice processes and/or the implementation of earlier decisions, and accepting default alternatives and/or default settings of products. Where they describe concrete choices Thaler and Sunstein (2009, p. 37) mention loss aversion as an explanation for inertia referred to as 'a strong desire to stick with your current holdings'. In SP surveys inertia might thus cause non-response by interviewees who earlier agreed to respond, omitting the completion of parts of the questionnaire by those who responded, application of a 'random decision rule' and the choice of the 'no change' alternatives where possible as a consequence of loss aversion.

Based on analyses of the UK survey outcomes Bates (1999) and Mackie *et al*. (2001a) claimed that approximately the same values for time gains and losses of equivalent size could be found by introducing an inertia variable. It is obvious that such an inertia variable or status quo bias will be significant if many respondents exhibited loss aversion, see e.g. Van de Kaa (2010b). However,

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[11] See Statistics Netherlands website. During the considered period inflation was about the same for all income categories whereas the increase in purchasing power varied over the deciles between 3% and 9%.

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the authors posited that the inertia effect was a consequence of the experimental setting: 'inertia is a preference for the current situation in order to simplify the task of answering the SP questions' (Mackie *et al.*, 2001a, Sect. 2.1). In this paper this behaviour is denoted as the inertia bias, to discern it from the more general concept of inertia.

Obviously, Bates (1999) and Mackie *et al.* (2001a) presumed that the interviewees would consistently have followed utility maximization principles for their choices if they had not bothered about the compensatory calculations and comparisons of overall utility. The responses to the Dutch surveys make it possible to put this premise to a severe test. These responses were analysed under the premise that most people consistently use one choice behaviour strategy during successive choices in the same particular domain-context combination. This seems the least one might expect from any interviewee who demonstrated inertia as a deviation from common utility maximizing behaviour, as it is only a weak substitute for the complete, transitive and context-independent idiosyncratic preference order of UT.

After exclusion of respondents from the 1988 and 1997 surveys who did not complete all four SP questions that contained the 'status quo' alternative, 4035 car-driving respondents remained. Of these, 1247 (31%) consistently chose for the reference state whenever it occurred in the choice set. If this choice was the consequence of an inertia bias of utility-maximizing interviewees there were three options when dealing with the eight remaining SP questions:

-Leave these unanswered.

-Answer them randomly, or in a fixed order.

-Evaluate them in the compensatory way.

Sub (i): Seven respondents left these uncompleted and 23 more did not choose from at least four choice sets. Though the inertia bias may have caused the choice behaviour of these respondents it might just as well have been caused by unwillingness to choose any alternative implying a loss.

Sub (ii): No respondents were found who followed some 'fixed order' response (like A-B-A-B-A-B…). Amongst the responses were 46 unique sequences. Ten different sequences were chosen twice and four sequences threefold. All other sequences observed were chosen by at least four interviewees. It is easy to see that the chance that an individual selects a particular sequence of eight bi-optional choices is $0.5^8 \approx 0.004$ if the response to these eight questions is random. The chance that any particular sequence is chosen by two or more random choosers rapidly decreases and drops to virtually zero for four identical sequences. At most a part of the twice and threefold chosen sequences might thus be a consequence of random choice, implicating that less than about 70 respondents might have followed this strategy. Random choice also implies that the dominant and inferior alternative from a choice set should be chosen with about the same frequency. As 20 out of the 46 'unique' choice sequences, three out of the ten twin sequences and two of the four threefold chosen sequences contained the inferior alternative this supports the notion that at most some 70 interviewees concluded their choice for the status quo with a random choice from the other choice sets. Random mistakes and estimation errors by respondents who, apart from that, exhibited a loss-aversive choice behaviour strategy offer an alternative explication for most of these sequences. One should further consider that a significant number of respondents might have marked the status quo alternatives as a consequence of applying the random choice rule rather than deliberately exhibiting an inertia bias.

Sub (iii): UT could explain the eight 'other' choices of 338 respondents. Loss aversive appraisal of the 'other' choice sets, in agreement with PT, could explain 346 more responses that definitely violated UT principles as well as all but one of the 338 responses in agreement with UT. Nineteen respondents systematically selected the alternative with the lowest trip costs, and 35 more the one with the shortest duration. One cannot exclude the possibility that the application by some of

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these 'status quo' choosers of these simple lexicographic decision rules for the remaining choices is indicative of an inertia bias. However, a non-compensatory two-stage strategy starting with a conjunctive rule drawing on loss aversion, resulting in an empty choice set, followed by a re-evaluation of the initially rejected options with a lexicographic decision rule would do the same job, for example.

Summarizing, inertia presumably explains a part of both the non-response to any SP survey and the incomplete answering of the SP game. If incomplete records are disregarded and the survey results are properly expanded to the population level, as was done in the considered surveys, this will not bias the inferred VTTS. In the Dutch surveys 1247 respondents (31%) systematically chose the 'status quo' alternative from the four SP questions that contained them. The other choices of most of these respondents agreed with a consistent application of PT, UT or several well-documented non-compensatory strategies to all 12 SP questions. At most some 5% to 10% of these 1250 respondents completed the other eight SP questions in a way that might be consistent with an inertia bias. An inertia bias of utility-maximizing interviewees could thus have played a role in a few percent of all responses but the extent is too small to exert a more than marginal effect on the VTTS assessment. In the Dutch surveys it could definitely not explain the observed choice behaviour of most respondents who systematically chose the reference option. Their behaviour might thus be considered as genuine expressions of preferences that are consistent with their real-life travel choice behaviour.

4.4 Loss aversion in agreement with Prospect Theory

From the preceding sections it seems obvious that the difference in valuation between travel time savings and losses as observed in Figure 1 might be attributed to the loss aversion principle of PT. Figure 3 shows the corresponding λ_{time} values for different time changes. Except for low time changes the ratios are mostly in the range of 1.4 to 2.2, slightly lower than the 2.0 to 2.5 values reported by Kahneman (2002).

Often the loss aversion factor is presumed to be the same for both time and cost attributes. However, PT allows for different values of the loss aversion factor for different attributes. Tversky and Kahneman (1991, p. 1051) illustrated this with an indifference map in which the indifference curves were linearized and the loss aversion for both considered attributes differed. Figure 4 shows a similar indifference map with the trip expenses and trip duration as dimensions of the choice options and the reference trip duration and cost as reference state. It includes the coordinate system and quadrants as defined by Bates (1999) and Mackie *et al.* (2001a), see Figure 2 above. As an example, the loss aversion factor for time (λ_{time} = 2.5) was assumed to be well above that for monetary cost (λ_{cost} = 1.5). According to the principle of indifference maps the VTTS in the quadrants is equal to the negative slope of the indifference curves there. Figure 4 shows that the slope of the indifference curve in quadrant 1 is steeper than in quadrant 3 if $\lambda_{time} > \lambda_{cost}$ and thus the VTTS is higher. When $\lambda_{time} < \lambda_{cost}$ the slope is feebler in quadrant 3 and thus the VTTS is lower. Obviously, the slope and VTTS in quadrant 1 and 3 are the same if $\lambda_{time} = \lambda_{cost}$.

Figure 4 thus relates the VTTS values per quadrant in Table 2 to VTTS[PT], λ_{time} and λ_{cost} values as defined in agreement with PT. The best fitting values of the latter parameters were assessed by linear regression of the implied VTTS values per quadrant and the corresponding values in Table 2. The results are listed in Table 3, together with the coefficients of determination which demonstrate a good fit. As neither Bates (1999) nor Mackie *et al.* (2001) report goodness-of-fit data for their models this does not imply that this PT model offers a good approximation of their survey data nor does it exclude that another set of VTTS[PT], λ_{time} and λ_{cost} values would offer a better fit to these data than the four-quadrant-VTTS model.

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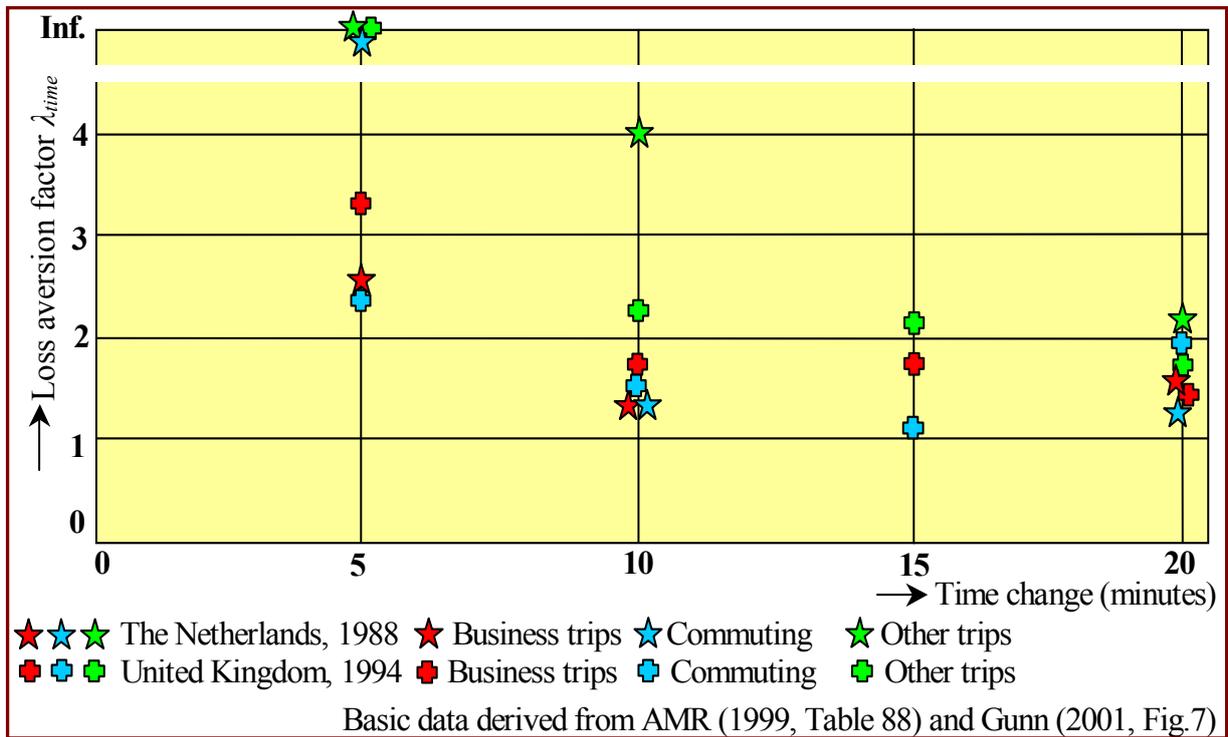
Figure 3. Mean loss aversion factors from original analyses of Dutch and UK VOT surveys
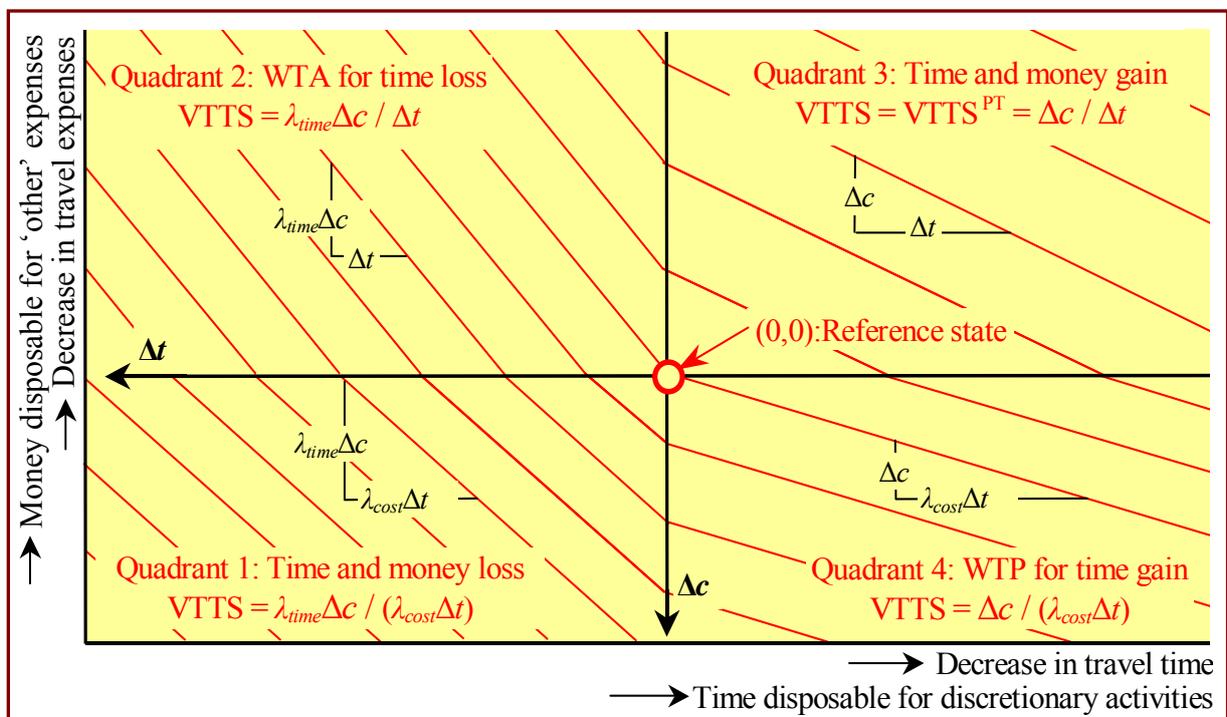
Figure 4. Linearized indifference map with loss aversion factors according to PT

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Table 3 VTTS^{PT}, λ_{cost} and λ_{time} calculated from VTTS values per quadrant

VTTS values per quadrant (see Table 2)	VTTS^{PT}	λ_{cost}	λ_{time}	R^2
From secondary analysis of logit values plot in Bates (1999)	8.1	4.3	2.0	0.905
From estimate of cost and travel time parameters in Bates (1999)	8.4	3.5	1.9	0.938
VTTS values for business trips in Mackie *et al.* (2001a)	12.7	2.4	2.0	0.997
VTTS values for commuting in Mackie *et al.* (2001a)	4.4	2.5	3.0	0.999
VTTS values for other trips in Mackie *et al.* (2001a)	3.7	2.5	3.5	0.999

The coefficients of determination R^2 follow from linear regression of the VTTS values per quadrant in Table 2 and the corresponding values calculated from the VTTS^{PT}, λ_{cost} and λ_{time} values.

The λ_{time} value for commuting in Table 3 is similar to that found from the preliminary analyses of the first Dutch survey (HCG, 1990, p. 21) but higher than the 'average' value (app. 1.8) one might infer from Figure 3. For business trips the λ_{time} values are about the same. Particularly for 'other purposes' Figure 3 exhibits an extreme size effect in λ_{time}, caused by a zero value for small time gains and a finite value for small time losses. The model specifications used to arrive at the data in Table 3 did not consider such a size effect. The size effect might thus at least partially explain the high λ_{time} value of 3.5 found for 'other purposes' in Table 3. In view of the large differences in model specifications and in the degree of data aggregation that were used to arrive at the data in Figure 3 and Table 3 the overall agreement between both sets might be considered as fair.

Up to now the Dutch 1997 survey has not been analysed for the potential occurrence of loss aversion. A first step was to investigate whether loss-neutral utility maximization could explain the stated choices of the majority of the respondents. To test this, the 2x12 alternatives submitted in the Dutch SP games and the 12 'boundary VTTS' values, that are the values for which each alternative in a choice set is equally attractive, were depicted in an indifference map similar to Figure 4. Also the percentages of the interviewees that chose each of the 2x12 options were categorized and plotted. Figure 5 shows the result for the 1294 car drivers who completed the questionnaire for trip durations of 46-90 minutes. From the principles behind this figure it is easy to see that at the population level, the median VTTS is equal to the boundary VTTS of a choice set if each alternative of that set is chosen by 50% of the interviewees. The median VTTS is higher than the boundary VTTS of each choice set for which the percentage that is indicated on the left-hand side of the concerned boundary line in Figure 5 is lower than 50% and vice versa. The opposite holds with respect to the percentages of the right-hand side alternatives. Of course, the more these percentages differ from 50%, the more the median VTTS differs from the concerned boundary value.

One should keep in mind that differences in the median VTTS inferred from the frequency of the choices from different choice sets cannot be attributed to interpersonal heterogeneity in taste templates and/or VTTS as all choice sets were evaluated by the same group of individuals. Of course, at the individual level random intrapersonal choice heterogeneity might explain such differences but in view of the almost 1300 respondents this effect will largely disappear at the population level. Significant differences in feasible VTTS ranges, for example between different quadrants in Figure 5, should thus be attributed to the employed choice behaviour strategies. Comparing the feasible median VTTS values in the different quadrants of Figure 5 with the expected values in agreement with UT and PT will thus reveal whether the majority of the considered population chose as if they applied the rules of UT and/or PT.

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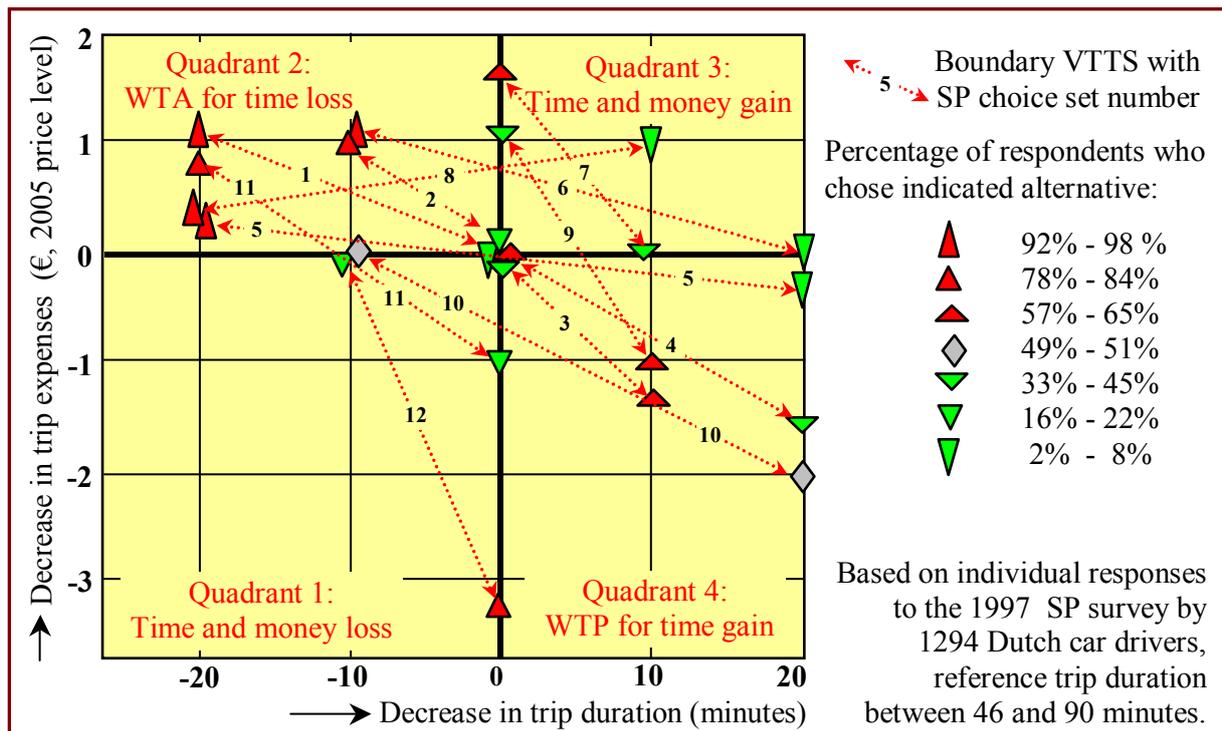
Figure 5 Stated choices of 1997 Dutch car drivers

It appears that both alternatives of SP10 were chosen by 50% of the interviewees. This implies a VTTS < €4.3/h in quadrant 4. The 60%-40% distributions of the preferences for the alternatives of SP 3 and 4 indicate a VTTS < €8/h and VTTS > €4.8/h. The higher VTTS suggested by the response to SP4 compared to SP10 might be a consequence of its greater distance from the 'zero discretionary available money' axis (see Figure 2). The VTTS in this quadrant would then vary between €4/h and €6/h. Figure 5 offers no indication that the 'status quo' alternatives of SP3 and 4 are valued higher than would follow from the trade-off with their feasible alternatives. Particularly the low frequency with which the status quo option of SP4 is chosen compared to the preference for the time loss-zero cost change alternative of SP10 and the cost gain-zero time chance alternative of SP 9 seems incompatible with such a 'status quo bonus'.

In quadrant 1 the choice distributions for SP10, 11 and 12 indicate a VTTS above €5/h and far below €19/h. Comparison of the frequency of preferences for the different alternatives in quadrant 2 does not suggest any 'status quo bonus' for the 'no change' alternatives of SP 1 and 2. Here, the very low preference for the dominated alternative of SP 8 does not come as a surprise. However, the preferences between 4% and 17% for the 'left-hand alternatives' of SP 1, 2, 5, 6 and 11 suggest very high VTTS values here. Those for SP 2 indicate a VTTS high above 6.4 €/h. In quadrant 3 the 58% preference for the left-hand side alternative of SP7 in connection with the 36% preference for that of SP9 indicate a median VTTS of between €9.5/h and €12.5/h.

According to the diminishing marginal rate of substitution principle of UT the indifference curves in Figure 5 should be concave and without a kink at the 'zero change' time and money levels. As the indifference map is bounded the VTTS will also decrease with increasing travel expenses if travel time is kept constant, and increase with increasing travel time if travel expenses are kept constant (see Figure 2). The submitted changes in trip times and expenses were between 10 and 45 % of the interviewees' reference trip. This implies that the VTTS in quadrant 2 might be slightly higher and in quadrant 4 somewhat lower than in the 'intermediate' quadrants 1 and 3. According to PT the indifference curves should be kinked at the 'zero change' time and money

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axes. The actually inferred median VTTS in quadrant 3 appears about twice as high as in quadrant 4 and that in quadrant 1 appears in between those in quadrants 3 and 4. The indifference curves are thus clearly kinked at the 'zero cost change' attribute level and presumably also at the 'zero time change' level. This demonstrates that the majority of the interviewees did not choose according to the choice behaviour strategy from the UT paradigm. The observed differences in median VTTS between quadrants 1, 3 and 4 indicate loss aversion factors in the 1.5 to 2.5 range. A majority of the choice statements can therefore be explained by assuming that the interviewees followed a choice behaviour strategy congruent with PT.

Similar maps of the responses for shorter and longer trip durations also indicated loss aversion factors above unity. One might conclude that this analysis of the Dutch 1997 data excludes loss neutral utility maximization as an explanation for the 'majority choice pattern' that the interviewees followed.

The logit analyses, drawing on stochastic interpersonal differences in size independent, loss-neutral utility maximization, as well as the 'majority-of-responses' approach above disregard interpersonal heterogeneity in choice behaviour strategies within the survey population. The occurrence of such heterogeneity was investigated by assuming that interviewees apply such choice behaviour strategies consistently during the successive choices that they make in the SP context. Theoretically, the choices from 12 bioptional sets allow $2^{12} = 4096$ different sequences. After the exclusion of respondents who did not complete all twelve SP questions those of 3949 car drivers from the Dutch 1988 and 1997 surveys were evaluated. The considered choice behaviour strategies were formulated in terms of a combination of VTTS[PT] and loss aversion factors for travel time and monetary costs. Because this is most commonly used both in UT and PT, only the linear additive value decision rule was considered. After assessing the choice sequences that follow from application of each strategy the percentage of the respondents with the same choice sequence was determined.

Table 4 Individual choice behaviour strategies of Dutch car drivers

VTTS[PT] (€/h)	< 1	1 - 5	5 - 10	10 - 20	> 20	Total
Choice behaviour strategy	% of respondents					
Strong lexicographic	2	-	-	-	13	15
UT ($\lambda_{time} = \lambda_{cost} = 1.0$)	2	6	3	10	13	34
PT ($\lambda_{time} = \lambda_{cost} = 1.5$)	2	10	10	12	13	47
PT ($\lambda_{time} = \lambda_{cost} = 2.0$)	2	12	8	17	13	52
PT ($\lambda_{time} = \lambda_{cost} = 2.5$)	2	11	10	4	14	41
PT ($\lambda_{time} = 2.0; \lambda_{cost} = 1.0$)	2	19	3	1	13	38

Source: individual responses of 3947 car drivers to the SP questions in the 1988 and 1997 Dutch VTTS surveys

The results of this analysis are tabulated in Table 4. Overall, the distribution of VTTS[PT] over the survey population seems far from random. It appears that the strong lexicographic rule drawing on a very high VTTS[PT] explains the most frequently observed sequence of answers. This sequence and the one following from the same rule applied by people with a very low VTTS[PT] are equally well explained by both UT and PT. In addition, UT could explain some 19% more of the sequences. With the exception of less than 1% PT could explain these as well. Another 23% of the responses violated the principles of UT but could be explained by decision frames and the associated loss aversion factors congruent with PT. Though there is some spread in loss aversion factors the most commonly mentioned factor 2 applied to both attributes gives the best fit. All tabulated combinations of loss aversion factors explained 56% of the observed choice sequences.

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One should realize that size effects and non-compensatory rules have not yet been analysed. Several non-compensatory rules might clarify individual size-dependent valuation and/or draw on loss-aversive behaviour.

To summarize, the majority of the choices made by the UK and Dutch interviewees in these surveys can be explained by reference-dependent framing as well as the loss-aversive and size-dependent valuation of attributes. The sets of VTTS values found by Bates (1999) and Mackie *et al.* (2001a) from aggregated outcomes from the UK survey can be expressed in one VTTS[PT] and two loss aversion factors. This reduction from four to three degrees of freedom hardly affected the conformity with the underlying data. The resulting loss aversion factors for travel time changes have the same order-of-magnitude as those assessed from a comparison of size-dependent VTTS values for the time gains and losses as reported by Gunn (2001) from a different model estimated for the same UK data. An analysis of the aggregated responses of the Dutch 1997 SP survey to the separate SP questions violated the principles of UT but the inferred VTTS[PT] and loss aversion factors were in agreement with PT. This analysis definitely did not support a higher appraisal of 'status quo' alternatives than would follow from a reference-dependent, loss aversive choice behaviour strategy. An analysis of the sequences of the choices from the 12 SP questions at an individual level, drawing on intrapersonal consistency in individual choice behaviour, shows a strong heterogeneity in choice behaviour strategies. It demonstrates that the choice sequences of a clear majority of the interviewees in both Dutch surveys can be explained by assuming that they behaved according to the principles of PT while only 34% of all choice sequences complied with the principles of UT.

5. Conclusions

This article considered several behavioural framing and judgment phenomena that might have biased the results of the very similar Dutch and UK SP surveys held between 1988 and 1997. This yielded the following findings:

-Hedonic framing and/or the employment of judgment rules related to the availability and cue familiarity heuristics might have biased the VTTS of travellers who were reimbursed for their trip. In the Dutch surveys the VTTS may have been overestimated by a few percent at the most. In future surveys one might arrange for a sample with sufficient numbers of reimbursed and not-reimbursed travellers in the relevant trip categories to control for such a bias in the VTTS.

-Though the Dutch SP questionnaires provided a highly accessible anchor, no solid evidence was found that the answers were affected by an anchoring bias. Comparison of average VTTS values from revealed preference data and from the 1988 survey reported in HCG (1990) shows a pattern that might to some extent be explained by such a bias but as the SP values were within the 95% confidence interval of the revealed data this does not offer solid proof for it. A bias might also have originated because the cost attributes of the choice sets in the Dutch 1988 and 1997 surveys had identical nominal levels. It was inferred that an anchoring bias would imply that particularly the VTTS for business trips and to a lesser extent for commuting would lag behind inflation. Both HCG (1998) and Gunn (2001) provide information, from different analyses of the Dutch SP data, that the development of the VTTS for other trips lagged more behind inflation than for business trips.

-Inertia will presumably explain a part of both the non-response to any SP survey and the incomplete answering of the SP game. As it is common practice to disregard incomplete records and to expand the survey results properly to the population level this will not bias the VTTS inferred from stated choice surveys.

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-An inertia bias may originate in an SP survey if a significant part of the interviewees choose 'status quo' alternatives without trading these with other alternatives to minimize their mental effort. In the Dutch surveys at most some 2% to 3% of all respondents systematically chose the 'status quo' alternative from the four SP questions that contained them *and* also completed the other eight SP questions in a way that might be consistent with an inertia bias. This extent is too small to exert a more than marginal effect on the VTTS assessment. Also an analysis of the aggregated responses to each separate SP question in the Dutch 1997 survey did not support a higher appraisal of 'status quo' alternatives than of alternatives that imply changes in the reference state.

These findings show that the sign effect as reported from the UK and Dutch SP surveys was not caused by an experimentally induced bias. The high frequency of choices for the status quo alternatives in the considered SP surveys might thus predominantly be considered as genuine expressions of preferences.

Several secondary analyses were performed to see whether PT would offer a better model for the explanation and description of the sign effect than UT. These yielded the following findings:

-The sets of VTTS values found by Bates (1999) and Mackie *et al.* (2001a) from aggregated outcomes from the UK survey can be expressed in one VTTS^{PT} and two loss aversion factors. The reduction from four to three degrees of freedom hardly affected the conformity with the underlying data.

-The resulting loss aversion factors for travel time changes have the same order-of-magnitude as those assessed from a comparison of size-dependent VTTS values for time gains and losses, as reported by Gunn (2001) from a different model estimated for the same UK data.

-An analysis of the aggregated responses to the separate SP questions in the Dutch 1997 SP survey showed that most respondents violated the principles of UT but the inferred VTTS^{PT} and loss aversion factors were in agreement with PT.

-An analysis of the sequences of the choices from the 12 SP questions at the individual level, drawing on intrapersonal consistency in individual choice behaviour, shows a strong heterogeneity in choice behaviour strategies. It demonstrates that the choice sequences of a clear majority of the interviewees in both Dutch surveys can be explained by assuming that they behaved according to the principles of PT while only 34% of all choice sequences complied with the principles of UT.

Summarizing, the VTTS found from the Dutch and UK SP surveys are at most marginally affected by hedonic framing, anchoring and inertia biases. The so-called sign effect cannot be explained by inertia let alone by an inertia bias. An analysis of the individual choice sequences reported from the Dutch surveys shows a strong interpersonal heterogeneity in choice behaviour strategies. Only a minority of the responses to the Dutch and UK surveys can be the outcome of a consistent application of a choice behaviour strategy as assumed in UT. The majority of the responses to these surveys can be explained by assuming reference-dependent framing, loss-aversive valuation of attributes and a compensatory decision rule in agreement with PT.

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References

AMR (1999). *The Value of Travel Time on UK Roads – 1994*. Accent Marketing and Research and Hague Consulting Group, The Hague.

Bates, J. (1999). Value of Travel Times on UK Roads 1994, An Assessment of the HCG/Accent Report. In AMR *The Value of Travel Time on UK Roads,* Accent Marketing and Research and Hague Consulting Group, The Hague.

Burge, P., Rohr, C., Vuk, G. and Bates, J. (2004). Review of international experience in VOT study design. Paper presented at the *European Transport Conference*, Oct. 2004, Strasbourg.

Cantillo, V. and Ortúzar, J. d. D. (2005). A semi-compensatory discrete choice model with explicit attribute thresholds of perception. *Transportation Research Part B,* vol. 39, no. 7, pp. 641-657.

De Borger, B. and Fosgerau, M. (2008). The trade-off between money and travel time: A test of the theory of reference-dependent preferences. *Journal of Urban Economics*, vol. 64, pp. 101-115.

DeSerpa, A. C. (1971). A theory of the economics of time. *The Economic Journal,* vol. 81**,** pp. 828-846.

Epley, N. and Gilovich, T. (2002). Putting Adjustment Back in the Anchoring and Adjustment Heuristic. In Gilovich, T., Griffin, D. and Kahneman, D. (eds) *Heuristics and Biases,* Cambridge University Press, New York.

Gilovich, T., Griffin, D. and Kahneman, D. (eds.) (2002). *Heuristics and Biases.* Cambridge University Press, New York.

Gunn, H. (2001). Spatial and temporal transferability of relationships between travel demand, trip cost and travel time. *Transportation Research Part E,* vol. 37, pp. 163-189.

HCG (1990). *The Netherlands' Value of Time study: Final report*. Hague Consulting Group, The Hague.

HCG (1998). *Value of Dutch Travel Time Savings in 1997 - Final report, a report for Rijkswaterstaat - AVV*. Hague Consulting Group, The Hague.

Hess, S., Rose, J. M. and Hensher, D. A. (2008). Asymmetric preference formation in willingness to pay estimates in discrete choice models. *Transportation Research Part E: Logistics and Transportation Review*, vol. 44, no. 5, pp. 847-863.

Jara-Díaz, S. R. (2002). The Goods/Activities Framework For Discrete Travel Choices: Indirect Utility and Value of Time. In Mahmassani, H.S. and IATBR (eds) *In Perpetual Motion: Travel Behavior Research Opportunities and Application Challenges,* Elsevier Science Ltd, Oxford, UK.

Kahneman, D. (2002). Maps of Bounded Rationality: A Perspective on Intuitive Judgment and Choice. In Frängsmyr, T. (ed) *Les prix Nobel 2002*, Nobel Foundation, Stockholm.

Kahneman, D. and Frederick, S. (2002). Representativeness revisited: Attribute substitution in intuitive judgment. In Gilovich, T., Griffin, D. and Kahneman, D. (eds) *Heuristics and Biases,* Cambridge University Press, New York.

Kahneman, D. and Tversky, A. (1979). Prospect Theory: An Analysis of Decision under Risk. *Econometrica,* vol. 47, pp. 263-291.

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or Exposure of Genuine Preference?

Kahneman, D. and Tversky, A. (1984). Choices, Values, and Frames. *American Psychologist,* vol. 39**,** pp. 341-350.

List, J. A. (2004). Neoclassical Theory versus Prospect Theory: Evidence from the Marketplace. *Econometrica*, vol. 72, no. 2, pp. 615-625

Mackie, P., Fowkes, T., Wardham, M., Whelan, G. and Bates, J. (2001a). Three controversies in the valuation of travel time savings. Paper presented at the *European Transport Conference*, Sept. 2001, Cambridge, UK.

Mackie, P. J., Jara-Díaz, S. and Fowkes, A. S. (2001b). The value of travel time savings in evaluation. *Transportation Research Part E,* vol. 37**,** pp. 91-106.

McFadden, D. L. (2001). Economic Choices (revised version of Nobel Prize Lecture). *The American Economic Review,* vol. 91, no. 3, pp. 351-378.

Metcalfe, J., Schwartz, B. L. and Joaquim, S. G. (1993) The Cue-Familiarity Heuristic in Metacognition. *Journal of Experimental Psychology, Learning, Memory, and Cognition,* vol. 19**,** pp. 851-861.

Payne, J. W., Bettman, J. R. and Johnson, E. J. (1993). *The adaptive decision maker*. Cambridge University Press, New York.

Rizzi, L. I. and Ortúzar, J. d. D. (2003). Stated preference in the valuation of interurban road safety. *Accident Analysis and Prevention,* vol. 35, pp. 9-22.

Stanovich, K. E. and West, R. F. (2000). Individual differences in reasoning: Implications for the rationality debate? *Behavioral and Brain Sciences*, vol. 23, pp. 645-726.

Thaler, R. H. (1980). Toward a positive theory of consumer choice. *Journal of Economic Behavior and Organization*, vol. 1, pp. 39-60.

Thaler, R. H. (1999). Mental Accounting Matters. *Journal of Economic Behavior and Organization*, vol. 12, pp. 183-206.

Thaler, R. H. and Sunstein, C. R. (2009). *Nudge, Improving Decisions About Health, Wealth, and Happiness,* Penguin Books Ltd., London.

Tversky, A. and Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science*, vol. 185, pp. 1124-1131.

Tversky, A. and Kahneman, D. (1991). Loss aversion in riskless choice: a reference-dependent model. *The Quarterly Journal of Economics,* vol. 106, pp. 1039-1061.

Tversky, A. and Kahneman, D. (1992). Advances in Prospect Theory: Cumulative Representation of Uncertainty. *Journal of Risk and Uncertainty,* vol. 5, pp. 297-323.

Van de Kaa, E. J. (2005). Heuristic Judgment, Prospect Theory and Stated Preference Surveys to Elicit the Value of Travel Time. Paper presented at the *European Transport Conference*, Oct. 2005, Strasbourg.

Van de Kaa, E. J. (2008). *Extended Prospect Theory. Findings on Choice Behaviour from Economics and the Behavioural Sciences and their Relevance for Travel Behaviour*. Delft, TRAIL Research School.

Van de Kaa, E. J. (2010a). Applicability of an Extended Prospect Theory to Travel Behaviour Research: A Meta-Analysis. *Transport Reviews*, DOI: 10.1080/01441647.2010.486907.

Van de Kaa, E. J. (2010b). Prospect Theory and Choice Behaviour Strategies: Review and Synthesis of Concepts from Social and Transport sciences. *European Journal of Transport and Infrastructure Research*, vol. 10, no. 4, pp. 299-329.