APPLYING BEHAVIOURAL ECONOMICS IN THE DESIGN OF TRAVEL INFORMATION SYSTEMS

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Abstract

Providing information about transport-related attributes such as travel time, travel costs or carbon emissions might be seen not only as a service to the public, but as also an instrument to change their travel behaviour. While rational man theory suggests that individuals base choices on the attributes of the choice set (information content), the way information is being presented (information context) has also a strong effect on travellers' behaviour. "Choice architecture", through the design and incorporation of small features in the environment of choice making ('nudges'), could help individuals to overcome cognitive biases, and to highlight the better choices for them - without restricting their freedom of choice. This paper sketches a few of the more interesting among insights from behavioural economics, and suggests examples of how they might be useful for influencing travel behaviour through the design of travel information and help promoting desired travel options.

1. Introduction

Concerns over climate change, air pollution, health and congestion on the road network, coupled with falling oil reserves, are leading governments to take action to change the way people travel. Individuals are being encouraged to travel in more efficient and sustainable ways. Alongside the more 'traditional' interventions, such as economic measures, legislation and enforcement (which are considered by many as limiting their freedom to make travel choices), 'softer' interventions to change travel behaviour are also being also explored, as alternative or supplementary measures (Avineri and Goodwin, 2010). The provision of travel information about transport-related attributes such as travel time, travel costs or risks might be seen not only as a service provided to the public, but as an instrument to change travel behaviour. The presumption is that individuals, provided with travel information, can make more fully informed choices which will be to their personal advantage and potentially that of the transport system as a whole. However, some, expectations of big effects from new information systems have remained unrealized (Chorus et al., 2006).

The behavioural assumptions on responses of individuals to travel information, commonly applied in the design of Advanced Traveller Information Systems (ATIS), can be traced back to economic theory and the paradigm of rational man. Ben-Akiva and Lerman (1985, p.32) describe the theory of choice as a collection of procedures that define the following elements: (i) decision maker, (ii) alternatives, (iii) attributes of alternatives, and (iv) decision rule. The attractiveness of an alternative in the mind of the traveller is described as a vector of the attributes values (which is later reduced to a scalar, 'utility', as an index of the attractiveness of an alternative). As travellers are expected to act as rational human beings, and specifically to exhibit consistency and transitivity in their choices (ibid., p. 38), than the way alternatives and attributes are presented to the traveller should not matter much. However, as illustrated in this paper, it is not just the information content that may be influential; travellers may also be affected by the manner in which information is presented (its context). The main purpose of this paper is to illustrate and discuss the potential application of some of the insights from behavioural economics and their relevance to the design of ATIS. There has been so far only limited literature on context effects in the design of ATIS (Waygood and Avineri, 2011a) and choice architecture has not been applied and evaluated in a this context. Therefore its effectiveness remains an open question, which is not addressed in this paper.

2. The Promise of Behavioural Economics

Behavioural economics is an emerging body of work seeking to understand behaviour by incorporating insights from behavioural sciences into economics. The approach differs from conventional economics mainly by giving more weight to what are sometimes called 'irrational' motives and behaviours (Avineri and Goodwin, 2010).

Research in behavioural sciences, especially cognitive psychology, indicates that individuals' choices in a wide range of contexts deviate from the predictions of economic theory which largely assume a rational behaviour. Some of these deviations are systematic, consistent, robust and largely predictable. Evidence on systematic deviations from rational models have mainly emerged from studies on consumer behaviour, financial behaviour, health behaviour and more recently – travel behaviour (Tversky and Kahneman, 1974, 1992; Kahneman and Tversky, 1979; Avineri and Prashker, 2003, 2004). The "predicted irrationality" (Ariely, 2008) of individuals could (and some argue that it should) play a role in the design of behavioural change interventions. Thaler and Sunstein (2008) advocate the use of 'choice architecture' to influence behavioural change: 'Nudges', small features designed in the environment of choice making, could help individuals to overcome cognitive biases, and to highlight the better choices for them – without restricting their freedom of choice, and without making big changes to the physical environment, the set of choices, or the economic attributes of the choices. Following are some examples of nudges applied to different contexts.

The power of Defaults

People are influenced by 'defaults' set to them by the designers of information systems. It is often impossible for private and public institutions to avoid picking some option as the default. Picking 'smart' defaults is a way to nudge towards specific choices. Enrolling people automatically into savings plans, while allowing them to opt out, is an example of a successful nudge. Organ donation policies that make use of opt-in defaults and presume consent are more successful than others (Thaler & Sunstein, 2007). In the context of ATIS design, in response to user's query on travel alternatives, the system could present by default (or prioritize through 'semantic framing') the more desired choices (i.e. sustainable modes such as walking, cycling or public transport will be presented by default). As other choices are represented as well on the choice set, this might be seen as a 'libertarian paternalism' approach that does not limit or enforce the choice.

Framing and "Loss Aversion"

People tend to feel and behave differently when information is presented (or 'framed') in terms of gains or losses. The emotion of loss is stronger than that of gain. The framing of choice outcomes as gains or losses could encourage individuals towards a specific choice. Examples and discussion on the application of gain/loss framing are provided in section 3.

Salience

Without feedback, a behavioural change is less likely. Direct feedback on energy consumption (e.g. meter reading; interactive feedback via a PC) was found to have an impact ranged from 5% to a 15% reduction in energy use (Darby, 2006). Some Advanced Vehicle Control and Safety Systems (AVCSS) provide the driver with high-pitch sound alert when driving over the speed limit or when leaving a lane. This warning signal serves as a nudge to provide the driver feedback on her/his behaviour and avoid driving behaviour that leads to the sound alert. A specific challenge ATIS designers are faced with is how to inform travellers about the environmental costs of their journeys. Carbon emissions are invisible to travellers; it is therefore difficult for them to associate their travel behaviour with environmental costs.

Grass roots

Individuals are influenced by 'significant others', people in their social networks, and people who have geographical and social proximity (neighbours, work colleagues, class colleagues). For example, energy bills that provide information on how energy efficient their neighbours are encouraged them to use less energy (Schulz et al., 2007). The small-scale group-based approach applied in the EcoTeams case study (Nye and Burgess, 2008) provided supportive social context that is accounted as one of its major success factors. Workplace and school travel plans also operate within a community which is limited in size and may encourage pro-social behaviour using 'bottom-up' approaches (Avineri and Goodwin, 2010). Exploring social processes occurring when a small group of commuter cyclists interacted with one another through a specially designed, web-based travel information platform, Bartle et al. (2011) explored the process of sharing travel information through a 'bottom-up' web-based service and suggested that it perform not only a functional role in diffusing practical travel information, but also a social one whereby perceived in-group membership reinforced positive views of cycling as a commuter mode. Both roles were thought to offer encouragement to those who are new to cycling or new to a particular workplace.

The next sections illustrate the potential design of a specific nudge - gain/loss framing - into the design of travel information to promote transport alternatives.

3. Gain/Loss Framing of Travel Choices

It was generally observed that in the evaluation of choices people treat gains and losses differently. The choice outcomes evaluated by the decision maker are mapped as 'gains' or 'losses' relative to some reference point. Such a reference point may be the current asset position, but may be influenced by the presentation of the outcomes or expectations of the decision-maker. People tend to feel and behave differently when information is presented (or 'framed') in terms of gains or losses (Kahneman and Tversky, 1979; Tversky and Kahneman, 1992; Thaler et al., 2007). This observed behaviour, called loss aversion, refers to the fact that people tend to be more sensitive to decreases in their wealth than to increases. Roughly speaking, losing £100 produces a negative feeling which is twice as intense as the positive feeling experienced when gaining £100. Tversky and Kahneman (1992) proposed the functional form of the value function as where x refers to the outcome expressed as a deviation from zero-asset position, that is, reference point, λ is the scale parameter, and α and β are parameters of the value function in the gain region and loss region, respectively (Eq. 1).

$$(1)\quad v(x) = \begin{cases} x^{\alpha} & if\, x \geq 0 \\ -\lambda(-x)^{\beta} & if\, x < 0 \end{cases}$$

The parameter $\lambda \geq 1$ represents the degree of loss aversion. For α, β< 1, the value function exhibits risk aversion over gains and risk seeking over losses. The parameters α, β ≤ 1 measure the degree of diminishing sensitivity. α=β=1 represents the case of pure loss aversion (see Figure 1).

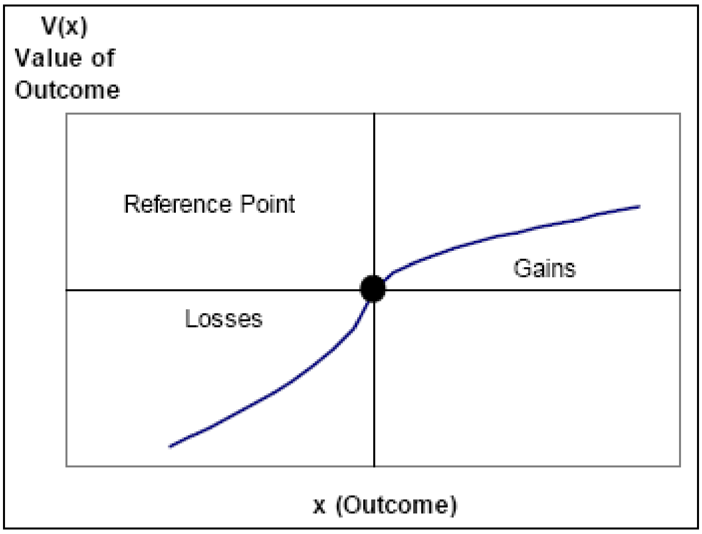

Fig. 1. A hypothetical value function (Based on Kahneman and Tversky, 1979)

Recent studies provide evidence that travellers exhibit aversion to loss and have a strong tendency to avoid choices associated with losses (Avineri and Prashker, 2004; van de Kaa, 2008, 2010). Avineri (2006) demonstrated how a change in the perceived value of the reference point in a route-choice problem could lead to improved traffic equilibrium.

Travellers, who are experienced with or informed about the cost, time and other attributes of transport systems, make their route, mode or timing choices in situations which are different from the decision making scenarios studied by psychologists and behavioural economics. In many travel choice contexts, travel time associated with an alternative choice is considered to be a major component of the general costs for the individual, and as an important attribute of the choice. Moreover, although the time and economic cost of a journey can be seen as 'losses' in many travel situations, some travel choices could be still perceived as psychological gains – if their cost or time are lower than those of other travel alternatives, or lower than some other reference value. It is the perceived loss or gain, measured in relative terms against a reference point, that is likely to be evaluated by the individual traveller (thus, it might be 'travel time saving' rather than 'travel time' itself that will make a certain route or mode choice seen as more attractive than the other).

Since people are more sensitive to 'bad outcomes' (losses) than to 'good outcomes' (gains), measured against some reference point, and since their choices can be influenced by the framing of the choice outcomes as gains or losses, we have been motivated to explore the relevance of the concept of gain/loss framing to the design of 'nudges' to encourage travellers towards a specific (and better) travel choice.

A simple nudge might apply the gain/loss framing in the provision of travel information. In presenting information on the attributes of different travel choices, let say the journey time, we could choose to present information in absolute time units, or choose one of the alternatives as the default choice – therefore implying its outcome as the value of the reference point, and highlight to the individual the relative gain or loss associated with the other alternatives.

Figure 2 illustrates the application of loss aversion in the framing of travel choices. It presents three ways of presenting the same information on the journey time of two options: car and cycle commuting.

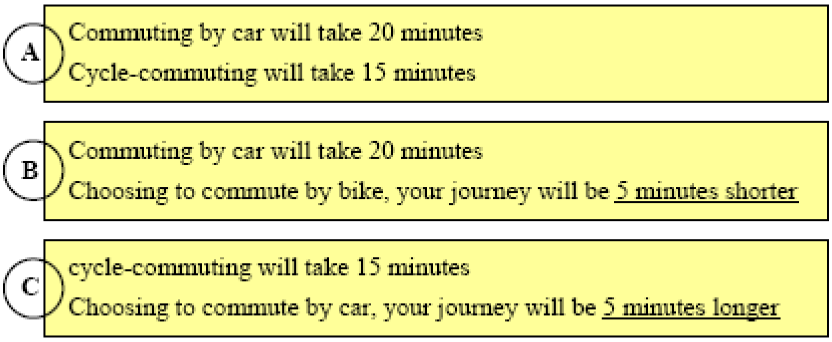

Fig. 2. Framing Effects: Three ways of presenting the same travel time information.

Under the rational choice model, the format of the information should not matter. The information presented by all three formats has the same content; it is the difference in how it is presented that could influence the choice – in a way that cannot be explained or predicted by classical economics.

It is difficult to predict how ‘unframed’ information on the options (alternative A) will be interpreted and used by the traveller. Framing cycling as a choice that carries possible gain with it (as illustrated in alternative B), or the even stronger nudge illustrated in alternative C (in which the choice of commuting by car is framed as a loss), are ways to make cycling appear more attractive than the car alternative. None of the information formats impose a restriction of the travel options for the traveller, or requires changes to the physical environment, and therefore can be seen ass a ‘soft’ measure. The traveller is encouraged, or ‘nudged’, to choose the option which is considered to be preferable.

Incorporating nudges, such as the one illustrated above, in the design of travel information could be incorporated in the design of a variety of information-based interventions. These could include web-based journey planners, carbon calculators or ‘tailored’ travel information provided to individuals and households who participate a Personal Travel Plan (PTP).

Waygood and Avineri (2011b) examined whether the design consideration of gain/loss framing could increase the perception of differences about the mass of travel-related CO2 emissions. This is different than the framing effects studied in the literature as the information on CO2 is not directly relevant and familiar to the individual; and therefore it is not obvious that the framing of such information as ‘gain’ or ‘loss’ will have an effect on individual’s perception, motivation or behaviour towards sustainable choices. Their experimental findings suggest that there are impacts from both loss framing and the scale of the CO2 being compared on how people perceived difference between alternative travel choices. Although behaviour change has not been evaluated in a direct way, it is assumed that as the perception of the difference between CO2 amounts is larger for loss framing, there would be an increased likelihood of the lower CO2 emissions choice being made by the individual who has been exposed to loss framing than the one exposed to gain framing.

The findings on another study (Waygood and Avineri, 2011a) suggested that people find it easier to rank the sustainability of travel choices if information on CO2 emissions is presented in the context of a recommended limit or budget. An important second consideration is that in real life there may be more than one choice that a person considers. In a situation of low background knowledge on CO2, those other choices will affect people’s interpretation of how sustainable something is. That effect, known as the anchoring effect, was found to have a significantly effect on sustainability ranking, and therefore more likely to stimulate desirable change to lower carbon choices.

4. Hedonic Framing

Thaler (1985) and Linveille and Fischer (1991) investigated individuals’ preferences for and responses to different framings of outcomes, mainly in the context of consumer behaviour. They have found that framing-manipulation affects subjects: Individuals proved risk averse when presented with value-increasing options; but when faced with value decreasing contingencies, they tended towards increased risk-taking. Based on the basic characteristics of the Prospect Theory's value function (see Figure 1), Thaler (1985) suggested four specific strategies to influence individuals' responses by the framing gain/loss components of the choices: (i) segregate gains; (ii) combine losses; (iii) offset small loss with a larger gain; and (iv) segregate small gains from large losses. Thaler (1985) tested the predictions of these strategies in financial choice settings at a laboratory environment. The works by Thaler and other behavioural economists have been mainly applied to the context of consumer behaviour. This section illustrates and discusses the relevance of hedonic framing and its potential application to the context of changing travel behaviour - mainly in the design of information-based behavioural change interventions to reduce car travel.

For simplicity, all strategies illustrated in this section involve no more than two or three outcome components; however the strategies can be easily generalized and applied to outcomes with a larger number of components.

4.1 Strategy 1: Segregate Gains

Because the value function is concave in gains (see Figure 1), a higher total value results a large gain when is decomposed into two (or more) small ones. For example, if public transport saves the traveller time (or money) in more than one lag of the journey – presenting the gains associated with different lags of the journey segregated rather than as combined would make the public transport choice seen more attractive. This could be illustrated by the following example:

A round trip is planned from A to B. The alternatives considered by the traveller are car transport and train. The driving time from A to B is 60 minutes, and the driving time from B back to A is (due to expected traffic congestion) 80 minutes. The travel time by train is 20 minutes each way. Consider the following two formats to present the time saved to the traveller by using the train alternative:

(i) out journey (A to B): travelling by train your journey is likely to be 40 minutes shorter compared with travel by car; return journey (B to A): travelling by train your journey is likely to be 60 minutes shorter compared with travel by car;

(ii) Travelling by train your total (two-way) journey is likely to be 100 minutes shorter compared with travel by car.

The functional shape of the value function suggests that the first framing might provide a stronger 'nudge' towards the train option, since (see Figure 3):

(2) $V(40)+V(60) > V(100)$

And generally, segregating a positive outcome to its positive components (or 'gains') might be considered as an effective strategy to highlight the benefits of this choice:

(3) $V(x)+V(y) > V(x+y)$ $x>0,\ y>0$

where x and y represent outcome components that are in the gains domain.

It is implicitly assumed in Eq. 3 that the value of the reference point is 0. However (and following the arguments in Avineri and Bovy (2008) on setting a value to the reference point), Eq.3 can be generalized to any value of reference point RP (RP could be positive, negative or zero):

(4) $V(x-RP)+V(y-RP) > V(x+y-2RP)$ $x>RP,\ y>RP$

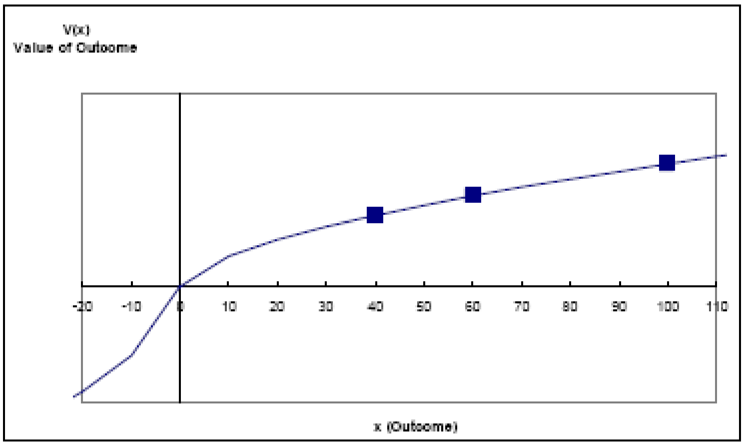

Fig. 3. Hedonic Framing. Strategy 1: Segregate Gains.

4.2 Strategy 2: Combine Losses

Since the value function is convex in losses (see Figure 1), combining two (or more) small losses into a larger loss will appear less ‘painful’ to the individual.

Following the example given in section 4.1, if public transport is the travel alternative that we would like to promote, but it might not perform very well in travel time saving, compared to the car alternative, it would be better to have all of the negative outcome components (or ‘losses’) combined to one large loss. This could be illustrated by the following example:

A round trip is planned from an origin A to a destination B. The alternatives considered by the traveller are car transport and bus. The driving time from A to B is 20 minutes, and the driving time of the return journey is 30 minutes. The travel time from A to B is 35 minutes by bus, and the return journey is 55 minutes. Consider the following two alternative formats to present the time lost to the traveller by using the bus alternative:

(i) out journey (A to B): travelling by bus your journey is likely to be 15 minutes longer compared with travel by car; return journey (B to A): travelling by bus your journey is likely to be 25 minutes shorter compared with travel by car;

(ii) travelling by bus your total (both-way) journey is likely to be 40 minutes longer compared with travel by car.

The functional shape of the value function suggests that the first framing will highlight the negative components of the bus choice, which will make it less desired. The second framing might be more effective in making the bus option seen not so bad compared with the car alternative.

As illustrated by Figure 4,

(5) $V(-40) > V(-15)+V(-25)$

And generally, combining the negative components of an outcome could be considered as an effective strategy:

(6) $V(x+y) > V(x)+V(y)\ \ x<0,\ y<0$

Notice that V(x+y) represents a negative prospect value, but its absolute size is smaller than the sum of prospect values V(x)+V(y).

Eq. 6 can be generalized as follows:

(7) $V(x+y-2RP) > V(x-RP)+V(y-RP)\ \ x<RP,\ y<RP$

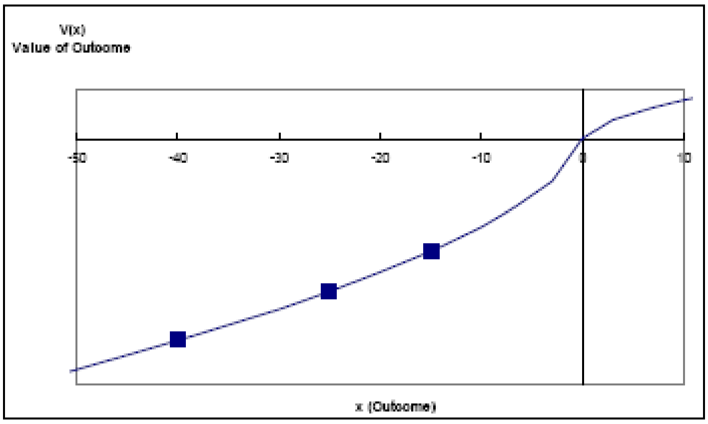

Fig. 4. Hedonic Framing. Strategy 2: Combine Losses.

4.3 Strategy 3: Offset a Small Loss with a Larger Gain

As discussed at the beginning of section 4, a travel activity could have both positive and negative utility components. The hedonic framing of mixed outcomes is illustrated by Strategy 3 (a mix of small loss and large gain) and strategy 4 (a mix of small gain and large loss). According to Thaler (1985), if a certain choice involves a small lost against a large gain, it would be better to have them combined. This strategy is directly derived from the greater steepness of the value function in the loss domain (see Figure 1), or for values $\lambda>1$ in Eq. 1.

The next example illustrates how first class rail journeys can be promoted to business travellers – and framed (against regular train journeys) as an opportunity to gain an increase in the productive work time, at a certain cost (more expansive ticket). Let's assume that a first class journey is more expansive than a regular one by £20, but at the same time provides a better working environment for business travellers that could increase the productivity of their work time during the journey which is valued by £30. Rail travel would be better promoted if the additional cost of the journey (x) will be offset by the improved productivity (y):

(8) $V(10) > V(-20)+V(30)$

As illustrated in Figure 5. Or, in more general terms:

(9) $V(x+y) > V(x)+V(y)$ $x<0,\ y>0,\ |x|<y$

for *RP=0*, and

(10) $V(x+y-2RP) > V(x-RP)+V(y-RP)$ $x<RP,\ y>RP,\ x+y>2RP$

for any value of RP.

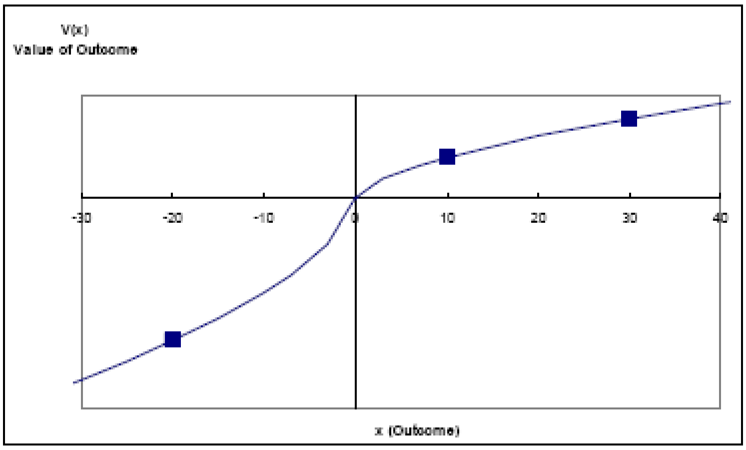

Fig. 5. Hedonic Framing. Strategy 3: Offset a Small Loss with a larger Gain

4.4 Strategy 4: Segregate Small Gains from Large Losses

Similar to the argument about offsetting a small loss with a larger gain (strategy 3), and due to the greater steepness of the value function at the losses domain (λ>1 in Eq. 1.), it is argued that a higher (less negative) total value results when we segregate small gains from a large loss.

Consider a situation in which a traveller could obtain a travelcard which will provide her a discount on a rail ticket fare. What would be seen as a more attractive framing: one that presents information about the discounted fair, or one that presents information on the full-price fare and the level of discount? Let's assume that the full price of the rail journey is £50 and the discount provided to travelcard users is 20% (£10). The cost of rail travel might be seen as a loss to the traveller; however the discount itself could be seen as a small 'gain'. From the functional shape of the value function it can be concluded that the second framing alternative will make the travelcard option seen as more attractive, or (as illustrated by Figure 6):

(11) V(10)+V(-50) > V(-40)

And generally, segregating small gains from large losses could be considered as an effective strategy:

(12) V(x)+V(y) > V(x+y) x>0, y<0, x+y<0

for *RP=0*, and

(13) V(x-RP)+V(y-RP) > V(x+y-2RP) x>RP, y<RP,

x+y<2RP

for any value of RP.

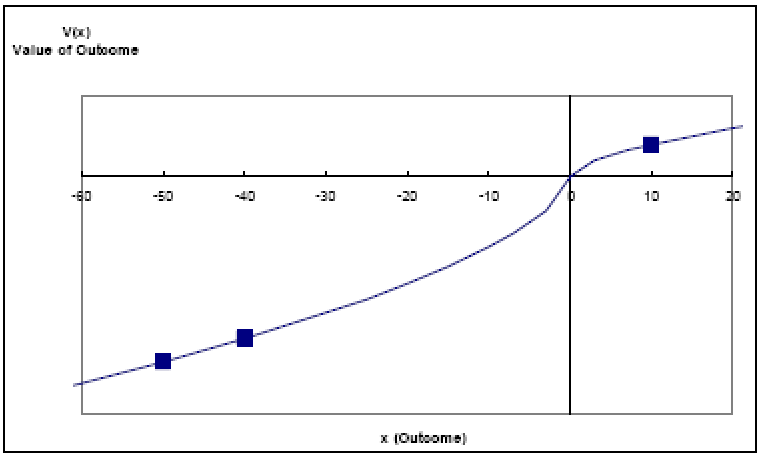

Fig. 6. Hedonic Framing. Strategy 4: Segregate Small Gains from Large Losses

5. Summary and Discussion

In this paper we have introduced and illustrated the relevance of framing strategies to the design of information based intervention and the incorporation of nudges to influence travel choices.

The general design process could be as follows:

(i) Identify a relevant dimension of the choice attributes (for examples travel time, travel cost, carbon emissions generated, etc); the dimension might be relative (for example, travel time savings);

(ii) Estimate the outcomes for each choice;

(iii) Identify the relevant reference point (see review of approaches to set a value to the reference point in Avineri and Bovy (2008));

(iv) Identify what might be considered by the individual traveller as the positive and negative components of the outcomes (‘gains’ and ‘losses’);

(v) Judge whether it would be realistic and natural to segregate or combine outcome components in the context of the problem;

(iv) Apply choice architecture – evaluate the effect of different framing strategies;

(v) Test and validate the effectiveness of the chosen framing against a ‘traditional’ framing that does not incorporate nudges (could be done evaluated through a small-scale pilot).

While this paper discussed the relevance of applying prospect-theory in the design of ATIS, framing could be applied in a wide range of measures to change behaviour. For example, in the application of road pricing schemes, the effects of the economic intervention could be strengthen by highlighting the negative components of the more congested route. For example, a congestion charge can be segregated to several of its components, each of them presented in negative value.

The design of framing strategies illustrated in this paper is largely assuming the existence and significance of loss aversion among individuals. Loss aversion has been exhibited in a range of behaviours tested mainly in static (‘one-shot’) settings, with limited feedback or incentives. However, some recent studies have questioned this paradigm, mainly in dynamic settings (repeated choice) that feature feedback (Ert and Erev, 2008). Therefore effectiveness of the framing strategies described in this work is subject to the decision making environment – such as its dynamic nature and the level of feedback provided to the individual.

In addition, Avineri and Goodwin (2010) argue that one of the limitations of the ‘nudge’ strategy is that being designed to influence individuals’ behaviour through intuitive and impulsive processes of the automatic system they do not address the fundamental problem of behavioural change. Nudges, such as the hedonic framing strategies illustrated in this paper, do not lead directly to a real change to the individual's knowledge, attitudes or values, and they are not designed to change the decision making process in the reflective system, and of course they do not make an objective improvement to the choice set. It is therefore might be difficult to maintain and achieve long-term and sustainable behavioural change just by designing measures that are based on the nudge approach.

Our goal in this paper has been to illustrate a new approach to incorporate insights from prospect theory and the nudge approach to the design of behavioural change measures, and to stimulate discussion on its relevance to the design of travel information systems. In specific it has demonstrated how (and why) framing strategies of gains and losses play an important role in influencing travel choice behaviour. It has been generally argued (with some support from empirical findings) that in the context of travel choice, the way travellers perceive and evaluate travel choices could be much influenced by the context in which travel information is being presented to them.

However, the nature of travellers' choice making is ultimately an empirical issue. In this respect, in order to reach better descriptive models of travel choice behaviour, and to validate the effectiveness of nudges such as those discussed in this paper, empirical studies should be conducted. More empirical research into individuals' responses to different framings of information is needed in order to validate the hypothesis about risk aversion and test the effectiveness of the hedonic framing strategies.

Understanding the role of framing on travel choices can help us to improve understanding of travellers' responses to information - and may be valuable in the design of ATIS (such as web-based journey planners, navigation and wayfinding devices, or in-vehicle information systems), and in the design of other information-based behaviour change measures (for example as part of a personal travel planning). Due to the lack of empirical findings, the significance and effectiveness of framing in making a change in travel behaviour remain largely unknown.

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