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by

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Abstract

Recent research suggests that, in some situations, numeric information may lack the 'evaluability' of visual representations of the same data. In such cases, reliance upon numeric information exacerbates tendencies for survey respondents to rely upon heuristics rather than their underlying preferences in formulating responses. Adapting such insights to the field of non-market valuation, for certain environmental goods, information on increases or decreases in the numeric levels of an attributes may trigger reliance upon the loss aversion heuristic, leading to an exacerbation of the well know gains/loss asymmetry problem (Horowitz and McConnell, 2002).

A split sample choice experiment (CE) is described in which standard approaches to conveying a land use change scenario (relying principally on numeric information) are contrasted with an alternative treatment in which objectively identical information is presented in visual form via virtual reality (VR) visualisations. A third treatment combines both formats. Results show that the gains/loss asymmetry is roughly twice as strong under a conventional numeric CE design than in the presence of visual information. The combined VRCE methodology developed in the paper therefore significantly ameliorates this pervasive anomaly and, we contend, represents an exciting prospect for the incorporation of complex real world environments within economic analyses.

Keywords: gains/loss asymmetry; loss aversion; non-market valuation; choice experiments; virtual reality; land use change; coastal zones.

1. INTRODUCTION

Economic theory postulates that an individual's choices regarding trade-offs between goods will be dependent upon the attributes and services of those goods and the characteristics and preferences of that individual (Lancaster, 1966). However, given the virtually infinite variety of goods and provision changes which could conceivably arise it would clearly be both highly inefficient and practically infeasible for individuals to invest time in determining prior preferences for all such options. Indeed, the existence of *prior* preferences is not required by economic theory (Carson, Groves and Machina, 1999). Rather it is assumed that individuals form their preferences as required but in accordance with the principles of economic theory.

An issue here concerns the formation process itself which some evidence suggests may not be an instantaneous process. Rather, certain commentators argue that theoretically consistent preferences are typically 'discovered' through experience and/or repetition (Binmore, 1994; 1999; List, 2003). Furthermore, as Braga and Starmer (2005) point out, the preference discovery process applies not only to learning about the good in question, but also to gaining understanding of the market institution through which it is to be provided.

The nature and speed of the preference discovery process becomes of particular importance in the case of the valuation of non-market goods through hypothetical surveys such as those used in contingent valuation (CV) or discrete choice experiment (CE) studies (Bateman et al., 2002). Some applications of these techniques present individuals with goods which they have little prior experience of (such as certain environmental goods) and employ hypothetical market institutions which individuals have never previously encountered. The standard approach to such problems is to ensure that question formats conform to the formal requirements of incentive compatibility (Carson, Groves and Machina, 1999).

The use of incentive compatible devices may well dissuade respondents from engaging in subterfuge and strategic behaviour; in other words, individuals may well answer as honestly as possible. Furthermore, a number of studies have shown that with fairly minimal encouragement respondents can set aside the hypothetical nature of non-market exercises and, presumably, answer as honestly as possible (Cummings et al., 1995). However, the preference discovery argument raises questions regarding whether such approaches are sufficient to elicit theoretically consistent responses and indeed evidence from experimental investigations of such formats is decidedly mixed[1]. If participants in valuation surveys lack experience of the goods and/or markets concerned then it is quite possible that they have been unable to form theoretically consistent preferences prior to their responses being collected.

Assuming, as seems reasonable, that individuals may find non-market valuation situations novel then how are responses formulated? Psychological insights into this issue suggest that, in such situations individuals will tend to 'construct preferences' using a variety of choice heuristics or 'rules of thumb' (Tversky and Kahneman, 1973; 1974; Slovic, 1995). Experimental investigations have shown that a common source of such heuristics are the characteristics of the question frame itself (see, for example, Ariely et al., 2003). Such framing effects have been identified within a number of CV studies (Kahneman, et al, 1999). For example, the bid-levels used in valuation questions have been shown to anchor subsequent responses (Johnson and Schkade, 1989; Green, et al., 1998 [2,3]), presumably

[1] Some studies find convergence of hypothetical with 'real' markets while other analyses report divergent results (see Cummings et al. 1997, Taylor et al 2001 and Burton et al 2001).

[2] Anchoring or starting point effects are one of the most well documented response heuristics, being replicated in a host of CV, economic and psychological studies (Kahneman et al., 1982; Kahneman and Tversky, 1982;

being interpreted by respondents as clues to the 'correct' value of the good under investigation. Preference construction therefore results in responses which are, from the perspective of standard economic theory, anomalous and unsuited for incorporation within decision making (Rabin, 1998).

Working on what seem (to the authors at least) reasonable assumptions that: individuals do not hold prior preferences for many provision change scenarios concerning non-market goods; that incentive compatibility alone is probably insufficient to induce instantaneous discovery of theoretically consistent preferences; and that individuals have no experience of most hypothetical market mechanisms; what strategy should be adopted for valuing changes in such goods? Of course one approach is to abandon such a venture on the grounds that a misleading estimate may be worse than no estimate at all (Diamond and Hausman, 1994)[4]. However, clearly a more desirable outcome is to successfully address the issue of preference construction and remove or at least sufficiently ameliorate the incidence of anomalies[5]. While highlighting the issue of preference construction, the psychological literature also provides insights into how reliance upon question frame and other heuristics might be reduced and hence anomalies ameliorated.

While many non-market valuation studies focus strongly upon the accuracy of information provided to survey respondents, psychological research tends to emphasise the 'evaluability' of that information (Hsee 1996a, 1996b; 1998; Slovic et al., 2004). Here the argument is that, unless individuals connect with and understand a piece of information on an emotional 'affective' level, then that information will (at least to some degree) lack meaning. Interestingly, an individual may on an objective level be able to acknowledge that say one numeric value is larger than another, but in the absence of evaluability then their response fails to tap into any underlying true preference. In such situations, rather than assisting with the decision making process, such information is liable to act as a heuristic spur for the construction of anomalous preferences.

There is a substantial, longstanding and ongoing literature showing that the presentation of information in visual form can, in many situations, greatly enhance its evaluability (Nisbett and Ross, 1980; Eagly and Chaiken, 1993; Hibbard and Peters, 2003). Early findings include the work of MacGregor and Slovic (1986) who show that visual displays outperform conventional information in terms of respondents being able to correctly assess factual outcomes. More recently Lipkus and Hollands (1999) show that visual information outperforms numeric data as a basis for the accurate comprehension of risk. Indeed the evaluation of health care risks has provided a number of examples where visual information has consistently outperformed equivalent numeric information as a route for minimising perception and judgement errors (Slovic et al., 2002; Peters et al., 2005a,b; Fagerlin et al., 2005; Zikmund-Fisher, et al., 2005). For example, Hibbard et al (2002) found that individuals asked to pick the best health insurance plan from an array of satisfaction ratings chose an inferior plan 45% of the time. However the simple addition of visual information reduced error rates to only 16%.

Roberts et al., 1985; Kahneman, 1986; Harris et al., 1989; Bateman et al., 1995; Jacowitz and Kahneman, 1995; Strack and Mussweiler, 1997; Chapman and Johnson, 1999; Epley and Gilovitch, 2001).

[3] Due to its single-response format it is impossible to test for anchoring within an incentive compatible single bound dichotomous choice format. Investigations of double, triple and one-and-one-half bound dichotomous formats all reveal clear evidence of anchoring (Cameron and Quiggin, 1994; Bateman et al., 2001, 2004). However, it is and will remain an open question as to whether this has any bearing upon the single bound method.

[4] Indeed some go further to argue for a move to non-economic approaches to decision making (e.g., Johnston, 1996; Jacobs, 1997; Sagoff, 2004).

[5] An interesting alternative is to give directly engage in the preference construction process, managing available heuristics so as to encourage the construction and internally consistent preferences (Hoeffler and Ariely, 1999; Gregory et al., 1993).

Psychological insights therefore suggest that a strategy for addressing anomalies within non-market valuation studies is to use of visual information to reduce uncertainty and unfamiliarity with the good concerned. Such a strategy of itself does not address the problem of a lack of familiarity with hypothetical market institutions. However, unlike the single shot CV approach, reliance upon the CE approach places the survey respondent within a context where they make repeated trade-offs between different specifications of the non-market good and alternative prices (Adamowicz et al., 1999; Louviere et al., 2000; Louviere, 2001; Bennett and Blamey, 2001; Holmes and Adamowicz, 2003; Hensher et al., 2005). This repetition provides experience of the hypothetical market and hence may reduce any anomalies arising from initial inexperience of that institution.

Adoption of the CE approach also has the attraction of investigating a format which, unlike the CV method (Carson, forthcoming), has received relatively little testing with respect to its vulnerability empirical anomalies within the field of non-market environmental valuation. Given that the number of CE applications to environmental goods is expanding rapidly (see, for example, Adamowicz et al., 1994, 1997, 1998; Boxall, et al., 1996; Bullock et al., 1998; Hanley et al., 2001a,b; Blamey 2002; Haab and McConnell, 2003; Champ, et al., 2003; Mallawaarachchi et al., 2001, 2006), then testing whether resultant values are readily suitable for incorporation within economic decision making, or highly prone to anomalies, is clearly a research priority.

Accepting the present lack of CE anomaly testing within the environmental context, what then are the likely candidates for response heuristics within such studies? To assess this consider the typical CE study which presents survey respondents with a series of options concerning the good in question. That good is described in terms of its defining attributes which are in turn varied across a range of numerical levels to define each option. The respondent is asked to choose between two or more of these options (one of which may be the status quo). This choice process is then iterated so as to build up a set of trade-off preferences for each respondent. Repeating this process across a sample (some of whom may be presented with choices between further options so as to extend the observation set) allows the researcher to efficiently gather a substantial data set concerning underlying preferences. This data can then be analysed to extract desired statistics such as the willingness to pay (WTP) for a given provision level of the specified good.

From an objective standpoint, providing that the attributes fully define the good then CE choice tasks are straightforward. However, given the psychological research discussed previously, a question arises concerning the evaluability of such tasks. One possible scenario is that respondents may objectively understand that say a numeric increase in the level of an attribute is a good (or bad) thing, but if they do not comprehend the magnitude of that change then the face value interpretation of responses is likely to be erroneous. For example, say that the CE concerns changes to instream flows in rivers used for water abstraction, a topic which has formed the subject matter for a number of valuation studies (see, for example, Duffield, et al., 1994; Willis and Garrod, 1999; Berrens, et al., 2000; Loomis et al., 2003; Collins et al., 2005). A technically accurate method for describing such flows might be in terms of increases or decreases in the flow level. It is trivial to assume that respondents will be able to distinguish an increase from a decrease and even a large increase from a smaller one. Furthermore, it seems likely that individuals will be able to classify changes as either utility improving or diminishing. However, unless respondents can bestow meaning upon different levels then they will lack evaluability. In such cases it seems that the continuous nature of an attribute level may be reinterpreted as say a category variable or at worse a simple discrete good/bad change.

In analysing and interpreting CE data, researchers implicitly adopt the face value assumption that responses relate to the attribute levels as specified (albeit in a potentially nonlinear

manner) rather than to some categorisation or binary interpretation of those levels. Yet the psychological evidence suggests that, to some extent, certain types of numeric level information may be less evaluable than visual presentations of the same information. Of course the extent to which such an effect arises will be highly dependent upon the nature of and familiarity with that information. One would not expect that numeric information on the cost of a scheme would cause any lack of interpretability. However, non-market valuation exercises often present respondents with less familiar attributes. Examples include:

- The level of instream flows (mentioned previously);
- Choosing between land use options including the area of teatree woodlands and the amount of vegetation along rivers and in wetlands, both measured in hectares (Mallawaarachchi et al., 2001);
- Asking respondents to choose between options defined by differing areas (in hectares) of urban, sugar cane and 'rare or unique vegetation' land use (Mallawaarachchi et al., 2006);
- The number of metres per kilometre of dry stone wall field boundary which would be restored under an option (EFTEC, 2006);
- Changes in the population of wild geese (Hanley et al., 2003).
- The percentage of lake acres and river miles with good water quality (Magat et al, 2000).
- Text descriptions of scenery along a recreational trail is (Hanley et al., 2001; Lindberg and Fredman, 2004)

In cases such as these, respondents can readily see whether the level of an attribute is increasing or decreasing and may well have preferences as to whether such changes are desirable or not. However, lack of affective connection with such attributes may well compromise their evaluability. Of course not all CE studies contain attributes which are likely to be non-evaluability. For example, many CE applications in the field of transport management comprises solely commonplace attributes. However, the likelihood of such problems arising seems much greater in the area of environmental valuation where attributes and/or their measurement units may be less familiar.

What then are the likely consequences of a given attribute, which is of importance to individuals, being presented in a poorly-evaluable manner? One possible outcome is that the attribute may effectively be ignored, resulting in a lack of scope sensitivity. This might then erroneously be construed as indicating that the attribute is irrelevant to the decision process. Another possibility, which may cause less readily detectable problems, is that the levels of the poorly-evaluable attribute may be reinterpreted by the respondent as heuristic cues for determining responses. Here, rather than reacting in a face value manner to the continuous levels used, respondents are likely to interpret attribute level changes as simply indicating good or bad things; as binary gains or losses. Such interpretation undermines the straightforward assumption underpinning the analysis of CE data and leads to erroneous parameter estimates and consequent implied values.

This reinterpretation of continuous changes as binary good or bad things is likely to trigger what is arguably the strongest and most well documented of all heuristics: gains/loss asymmetry. The tendency for people to strongly prefer avoiding losses than acquiring gains is, according to a recent review, the most intensively experimentally investigated of all

economic phenomena (Horowitz and McConnell, 2002)[6]. Psychological critiques contend that a major driver of this phenomena is the 'loss aversion' heuristic (Tversky and Kahneman, 1991; Kahneman, et al., 1991) whereas standard economic theory focuses upon income and substitution effects (Hanemann, 1991; 1999). Both theories allow for substantial divergences between the amount an individual is willing to pay (WTP) for a gain of a unit and the amount they are willing to accept (WTA) in compensation for giving up that unit[7]. However, there are other measures of welfare regarding which these theoretical perspectives differ. In particular Hicks (1943) defines the 'equivalent loss' (EL) measure as the amount an individual is willing to pay to avoid a loss. Standard theory states that this will be identical to the WTP measure. Conversely psychological insights and empirical tests (Bateman et al., 1997). suggest that if individuals employ the loss aversion heuristic to make choices then the EL measure will exceed WTP.

The above discussion provides the basis for our study. Psychological insights suggest that conventional, numeric descriptions of certain of the attributes featuring within CE studies of environmental goods lack evaluability. In such cases survey respondents are liable to resort to heuristics, notably loss aversion, to formulate responses. This will lead to a theoretically anomalous divergence between measures of WTP for gain and EL to avoid losses. The same psychological literature suggests that visual representations of these attributes may enhance their evaluability, reducing dependency upon the loss aversion heuristic and hence reducing if not removing the asymmetry between WTP and EL measures.

Recent advances within the field of virtual reality (VR) visualisation have opened up the possibility of directly addressing the evaluability critique of CE's by visualising the attribute levels which comprise a choice option. By so doing we can develop a new valuation methodology, the virtual reality choice experiment (VRCE) which relies upon visual cues to present complex environmental changes to individuals. In so doing this research combines the notion of 'evaluability' with the wider theory of naturalistic decision making (NDM) (see, for example, Orasanu and Connolly, 1993) which stresses the importance of including wider and more natural context within decision making. Harrison et al., (2005) argue that one of the major benefits of a VR based approach is the incorporation of such context allowing a move away from the highly focussed and abstracted environment of the typical economic experiment. The significant role of context has been demonstrated in many economics analyses (see, for example, Cooper et al., 1999; Harrison and List, 2003, 2004; and Camerer, 2003). In so doing this in turn addresses the 'focusing illusion' problem (Schkade and Kahneman, 1998)[8] in which experimental concentration on a given single good, presented in framework devoid of wider context, is liable to inflate respondents perceptions of the importance of that good and hence upwardly bias valuations of changes in provision.

In the following section we describe an experimental design to implement such a study. This concerns changes (both increases and decreases) in various types of land use (nature reserve, agricultural, etc.) within a specified area. The study employs state of the art VR

[6] Pertinently, Horowitz and McConnell find that the less a good is like an ''ordinary market good'' then the higher is the degree of gains/loss asymmetry. Given that the present study examines an environmental non-market good we should not be surprised to find substantial asymmetry within our resultant valuation estimates.

[7] Note that Sugden (1999) argues that it would take implausible levels of income and substitution effect to generate the levels WTA/WTP divergence observed in empirical studies. Furthermore, Bateman et al (1997) find that asymmetry persists even when controlling for standard theoretic drivers of the WTA/WTP disparity. Together this provides both theoretical and empirical support for the hypothesis that non-standard factors such as loss aversion are responsible for at least some of the observed asymmetry. This seems perfectly compatible with the Horowitz and McConnell finding that WTA/WTP differences are lowest for ordinary market goods, for which we might expect less loss aversion.

[8] The idea behind the focusing illusion can be summarised in the proverb that "Nothing is as important as when you think about it".

software to generate visual representations of environmental land use change options seen by a sample of CE participants. A split sample approach is used to contrast the choices of the latter group with those of a second sample faced with a conventional CE design in which objectively identical information is presented in numeric form. A third treatment is constructed by presenting a new sample with both the visual and numeric information. All respondents view the same full factorial design which allows for both gains and losses of each land use type and thereby the estimation of both WTP and EL values[9]. Contrasting these across treatments allows inspection of the degree to which the gains/loss anomaly occurs and is ameliorated or exacerbated by the differing modes of information provision. Subsequent sections describe our empirical results and present discussions and conclusions.

2. STUDY DESIGN: ATTRIBUTES, HYPOTHESES AND VIRTUAL REALITY VISUALISATIONS

Attributes

Given the above concerns regarding the evaluability of attribute and levels, we decided to focus upon one of the most common application areas within the field of environmental valuation; land use change. Such subject matter is in principle highly suitable for both numeric and visual presentation of information, although to date applications have only employed numeric approaches. The land use change issue is also ideally suited to the use of both increases and decreases in attribute levels as land is employed between different uses.

A convenient case study issue presented itself in the form of an ongoing debate concerning management of the North Norfolk (UK) coast and in particular the coastal area at Holme. This low-lying site consists of a mix of two types of environmentally valuable land uses: freshwater nature reserve (which we subsequently denote '*Reserve*') and saltmarsh mudflats which are flooded at high tide ('*Flooded*'), the remainder of the area being farmed[10]. Both the *Reserve* and *Flooded* areas are determined by the degree of protection afforded by a series of man-made coastal defences. A number of options being actively considered by relevant authorities (Jude et al., 2003) which means that a plethora of trade-off possibilities exist between these land uses and defence expenditures (the final '*Cost*' attribute).

Creating Virtual Reality Visualisations of Land Use Attributes

The notion of using visual images within valuation studies is not a new one. Previous studies have employed a range of visual cues including artists impressions and maps (Willis and Garrod, 1992; O'Riordan et al. 1993; Bateman et al., 1995; 2001), and computer edited photographs and photomontages (Hanley et al., 1998; Fukahori and Kubota, 2003). As an extension of the latter approach, more recently a limited number of applications have used

[9] To date, and to the best of the authors knowledge, the present study provides the first comparison of EL and WTP measures within a CE framework. However, a small number of CE studies have reported significant WTP/WTA reference point asymmetries including an analysis of food attribute demand (Hu et al., forthcoming) and water services to residential households (MacDonald, et al., unpub.).

[10] Arguably stated preferences over land use and expenditure options could be influenced by positive values for changes to agricultural area. While this seems unlikely (given the long standing surplus of agricultural land), to allow for the possibility (and reinforce the notion that the overall study area is constant) the residual farmed areas were presented to respondents as part of each choice option. Note that this does not constitute a further CE design attribute as agricultural land area is always the difference between total area and the sum of the *Reserve* and *Flooded* area. Even if respondents do hold significant values for agricultural land within the study area, such preferences are of little interest to the present study and irrelevant to the issue of whether gains/loss asymmetries differ between the numeric and visual information treatments.

computer-generated still images to convey built environment design elements (Davies et al., 2002; Davis et al., 2000; Laing et al., 2002) and urban parks (Mambretti et al., 2005). However, ongoing advances in computing power have allowed the analyst both to consider a more varied array of landscapes, and to bring in features such as animation and user interactivity. In particular VR analysts have introduced routines to allow individuals to choose between scenarios (e.g. Bishop *et al.*, 2001; Stock and Bishop, 2002). Recent export capabilities and plugins available in conventional geographical information systems (GIS) such as ArcView and MapInfo, has generated a new generation of VR-GIS capable of interactive landscape visualisation (e.g. Lovett et al., 2002c; Huang et al., 2001; Zavala and Pou, 2000). Most recently systems such as those manufactured by SGI (SGI, 2003) and Evans & Sutherland (Evans & Sutherland, 2003), and software such as that from Multigen-Paradigm (Multigen, 2003) offer the opportunity to freely explore and interact with virtual worlds in real-time; increasingly there is the capacity to base those worlds on GIS data, for example via packages such as Terra Vista (Terrex, 2003)). It is this VR-GIS approach which we adopt in the present study.

In order to ensure that the options presented to respondents within a subsequent CE exercise were grounded in the reality of the study site, an initial analysis of the physical characteristics of the area was undertaken. Here a GIS was used to employ methods developed by Jude et al. (2004) to modify Ordnance Survey (OS) Land-Line.Plus 1:2,500 scale vector line data and produce a baseline digital map of the area. This allowed the researchers to examine possible land use change in the area under a matrix of flooding and flood defence scenarios (details given in Jude et al., 2005). This analysis identified an area of some 274 hectares where a continuous trade-off between the *Reserve, Flooded* and *Cost* variables was possible. This therefore constituted an ideal study area for our CE analysis.

In order to enhance the policy application of results, rather than 'invent' future virtual environments these were generated from data concerning the real world physical characteristics of the study area. To achieve this, the GIS was used to combine our baseline digital map with various other OS data resources including a digital elevation model representing the study site's topography (OS Land-Form Profile, OS Land-Line.Plus and OS Meridian) and large and medium scale line data edited and classified to provide a landcover map of both the study area and surrounding land to which textures representing changes in land use can be applied[11] (details of these processes and outputs are reported in Jude et al., 2004, 2005). This allowed the data-driven definition of a variety of future land use scenarios, all of which were within the bounds of possibility dictated by the natural characteristics of the case study area. VR representations of any given land use scenario could then be produced by importing the GIS data into a series of linked VR and imaging packages[12]. Some minor enhancements were added to further improve the evaluability of the VR images such as adding a greytone shading to areas beyond the study area to clarify that they would remain unchanged and employing a clear colour scheme to differentiate between *Reserve, Flooded* and agricultural land uses.

The resultant 'interactive' VR images permitted viewers to 'fly-through' the virtual environments created, taking whatever path and altitude they desired, landing at will and moving across the surface of the VR area. Representing such images within the confines of a two dimensional page is unsatisfactory and a superior approach[13] is to view the images

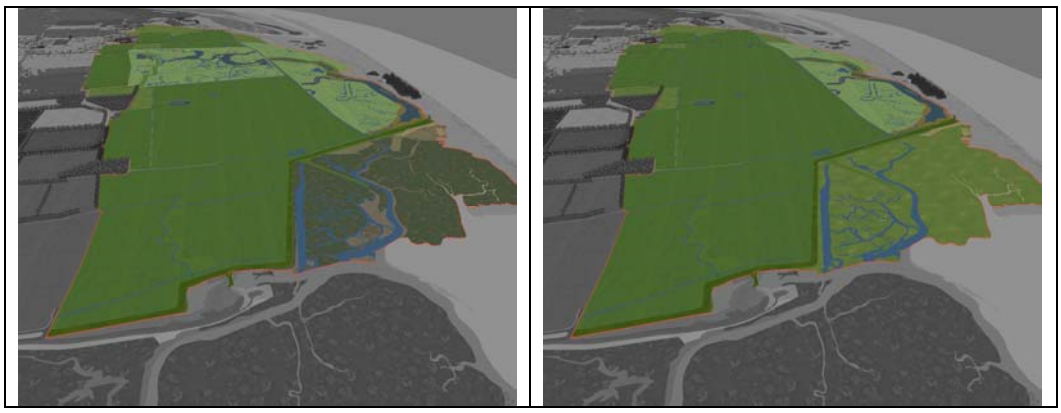
[11] Note that there were no buildings within the study area, however those nearby were identified using OS Address-Point data and three dimensional VR building models attached so as to enhance the realism of the resultant VR images.

[12] These include Terrex Terra Vista, MultiGen ModelBuilder3D, Audition Virtual Reality Viewer software, Bionatics REALnat and Adobe PhotoShop. Details are given in Jude et al., (2004, 2005).

[13] Even this is limited by the constraints of the internet. Representative flythroughs across the VR terrain can be obtained on request from the authors.

available at http://www.uea.ac.uk/~e154/research/visualisations/. However, for illustrative purposes only, Figure 1 presents screenshots of the flythrough starting points for the status quo and one alternative scenario.

Figure 1: Screenshots of the flythrough starting points for VR visualisations of the status quo (left hand panel) and one of the alternative land use scenarios (right hand panel)



One of the advantages of the design approach taken was that, once created, the VR environments could be readily exported to and run on conventional PC machines. This greatly enhances the potential for such applications to enhance the participatory decision making process (Appleton and Lovett, 2003, 2005; Lovett et al., 2003). However, for experimental purposes we wished to ensure that the amount of information given to each individual participant was constant. Allowing subjects freedom to determine their own investigation of each VR environment seemed likely to lead to individuals taking substantially different lengths of time to complete each choice task. Therefore, it was decided in this instance to use pre-set flight paths to describe the options in each choice task[14]. In conditions where experimental rigour is not an issue such a requirement could readily be relaxed.

Setting Attribute Levels and Finalising VR Visualisations

The status quo levels of our two focal land use attributes were approximately 93 and 30 hectares of *Reserve* and *Flooded* respectively. In order to allow for non-linear (and potentially asymmetric) preferences across both the gains and loss dimension, we required a minimum of four levels for each of our land use attributes; two of which had to be increases over the status quo and the other two being decreases (although which of these represents, in utility terms, a gain or a loss will be determined by respondents preferences). We were also interested in examining the effects of pushing attribute levels to zero. Using these requirements, attribute levels were determined so as not to seem too out of line with status quo values. Levels for the *Reserve* attribute were chosen as 0, 43, 112 and 149 hectares, while for the *Flooded* attribute levels of 0, 12, 95 and 125 hectares were used. In all cases the residual land use was retained as being farming. Combining the four levels of both of the land-use attributes plus the status quo gives a total of 17 possible land use permutations within the study area, each of which required a VR visualisation in order to be entered within our survey design. These visualisations were generated as discussed above.

[14] This was achieved via a simple Visual Basic program which delivered controlled viewing of preset fly-through files to participants using Quantum 3D Audition VR viewer software.

Turning to consider definition of our final *Cost* attribute, a pilot CV exercise concerning the Holme case study suggested that using the payment vehicle of increases in water utility bills had a number of advantages over other alternatives and that amounts of £1, £5, £10, £30 would provide appropriate levels for this attribute (Jude et al., 2003).

Testable Hypotheses

Our chosen attribute levels allow for trade-offs between money and either increases or decreases in both the *Reserve* and *Flooded* attributes. Responses therefore allow us to estimate measures of both WTP (for gains) and EL (to avoid losses). As discussed previously, standard theory suggests that marginal WTP should equal marginal EL for a given unit. Ideally we would want different individuals being placed at different status quo levels such that we could obtain WTP and EL measures for identical units of provision. However, short of misleading respondents about the current situation, we could only achieve such a design by telling asking them to imagine that they have moved from the current to some alternative status quo (with some respondents being told to move to a higher initial endowment while others move to a lower starting point). We have attempted such exercises before (Bateman et al., 2000) but that experience suggested that the degree of cognitive effort involved in such scenarios constitutes a serious limitation to such studies and this was avoided on this occasion. This does mean that a valuation curve exhibiting strong differences between marginal WTP and EL values is plausibly consistent with standard economic theory as we are comparing different units of provision (i.e. marginal rates are being taken from different points on the valuation curve). However, theory cannot explain any observed differences in the EL/WTP ratio between the numeric and virtual reality presentation modes; procedural invariance being the standard expectation. Conversely, psychological perspectives, which emphasise the greater evaluability of visual over numeric information, would predict that the EL/WTP ratio for the visual presentation treatments should be less extreme than that for the treatment where respondents receive numeric information only. This contrast in observed ratios provides the central test of our analysis and is formulated in the following hypothesis:

$$H_0 : \left(EL_i / WTP_i\right) = \left(EL_j / WTP_j\right)$$

where *i*, *j* denote information presentation mode treatment and $i \neq j$. As noted in the preceding paragraph, given the design of the study we have no prior expectation regarding the 'correct' value of the EL/WTP ratio (other than it should not be less than unity). However, loss aversion and our prior empirical results (Bateman et al., 1997) suggest that a value of EL/WTP > 1 is likely, indeed increased reliance upon the loss aversion heuristic should result in higher values of this ratio. More importantly, standard theory gives no reason to expect anything but procedural invariance across the various information provision treatments which characterise our experiment. Such procedural invariance will result in H_0 holding across all presentation treatments. In contrast, the arguments underpinning evaluability suggest that numeric information is likely to have lower evaluability than visual information. In such a case H_0 should be rejected with the EL/WTP being lower for presentations with greater evaluability (those including visual information) than when information is presented in a less evaluable manner (treatments relying solely upon numeric information provision).

Final design and survey administration

Combining the four levels for each of the *Reserve, Flooded* and *Cost* attributes dictates a full factorial design of 64 options. These were incorporated within a SQ+1 question format in

which each choice is between the status quo and a single, randomly selected option. In order to reduce cognitive load, each experiment participant faced a random draw of 16 choice tasks from the full factorial.

A computer-based survey was designed to administer the survey[15], with participants viewing all of the information and making their responses using a desktop PC in an experimental laboratory. The survey questionnaire comprised of several sections and was designed to be largely self administered following some initial introduction by the session facilitator. A set of introductory pages outlining the survey and how it worked were followed by a description of the management issues at the study site, and its characteristics. These included a series of photographs and maps as visual aids introducing the site and its attributes. Photographs of the *Reserve, Flooded* and agricultural areas of the study site were then presented to all participants so as to mimic the standard introductory information used in most good quality valuation studies. Figure 2 presents an example of this information, in this case showing the status quo location of agricultural land within the study area together with a photograph of this land type taken in-situ. Similar information was presented for the *Reserve* and *Flooded* attributes and a colour paper map of the site and its land uses under the status quo situation was also given to all participants from the outset of the experiment. Participants were then asked a number of simple 'warm-up' questions regarding their usage, perceptions and attitudes toward the North Norfolk coast.

Figure 2: Screenshot example of the introductory information presented to all participants in the experiment: Location and photo of agricultural land within the survey area

Once the base map and photo information was delivered to all participants, unbeknown to those subjects, the experiment then divided into three treatments. These were devised to

[15] The survey was written using HyperText Markup Language (HTML) and made extensive use of forms, with Javascript switching the images and information presented in each of the landuse option sets.

examine the hypothesised difference in gains/loss asymmetry arising from the use of visual as opposed to numerical information. In the first treatment, denoted *NUMERIC_ONLY*, the CE choice tasks faced by participants were presented in standard numeric form, as choices between the area of each land use type in the status quo and alternative options, both described through the numeric levels (in hectares) of each of the attributes. In the second treatment, denoted *VR_ONLY*, the status quo versus alternative choice tasks were presented solely as the VR flythroughs described previously. Finally, in the third treatment, denoted *VR&NUMERIC*, the participants were presented which choices described both as VR flythroughs and, beneath these, in standard numeric form[16]. In all treatments the level of the *Cost* attribute was always presented numerically. Furthermore, again in all treatments actual choices were only elicited after practice questions had been answered, allowing participants to familiarise themselves with the choice task and response mode. Once all choice tasks had been completed the three treatments again became identical and a series of personal characteristic questions were posed so as to elicit potential explanatory covariates. On completion of a survey, data was automatically stored and sent to the survey facilitator.

The experiment was conducted within the Social Science for the Environment, Virtual Reality and Experimental Laboratories (SSEVREL) at the Zuckerman Institute for Connective Environmental Research (ZICER) at the University of East Anglia. Participants were contacted through via an email invitation to all staff and students at the University (although only students chose to participate). Reference to the participants university username ensured that no individual could participate more than once in the experiment and subjects were instructed not to discus their experience with others and were unaware of the other treatments employed in the study.

3. RESULTS

In total 288 individuals participated in the experiment, each providing 16 choice responses. Table 1 details those central attribute and treatment variables analysed within our statistical analysis (details of the characteristics of the sample being presented in Jude et al., 2005). Cursory analysis showed a good spread of choices between the status quo and alternative.

Table 1: Variable definitions

Variable	Definition
Reserve	The area of freshwater nature reserve offered in the alternative scenario
Flooded	The area of saltmarsh mudflats, flooded at high tide, which is offered in the alternative scenario
COST	The increase in the *Cost* variable representing the additional amount of water bill tariff paid by the respondent for the alternative scheme
RESDIFF	The change in *Reserve* area from the status quo.
FLOODDIF	The change in *Flooded* area from the status quo
LOSS	= 1 if the change in *Reserve* or *Flooded* area represents a reduction from the status

[16] Screen-shots of each treatment are available from the authors.

	quo (e.g. if *RESDIFF*<0); = 0 otherwise (e.g. if *RESDIFF* > 0)
GAIN	= 1 if the change in *Reserve* or *Flooded* area represents an increase from the status quo (e.g. if *RESDIFF*>0); = 0 otherwise (e.g. if *RESDIFF* < 0)
VR_ONLY	= 1 if the respondent only saw the levels of the landuse attributes (*Reserve* and *Flooded*) presented via VR representation; = 0 otherwise.
NUMERIC_ONLY	= 1 if the respondent only saw the levels of the landuse attributes (*Reserve* and *Flooded*) presented via numbers of hectares; = 0 otherwise.
VR&NUMERIC	= 1 if the respondent only saw the levels of the landuse attributes (*Reserve* and *Flooded*) presented via both VR representation and numbers of hectares; = 0 otherwise.
*RESDIFF*LOSS*	Interaction term. Equals *RESDIFF* for all scenarios where the alternative offers a reduction in *Reserve* area from the status quo; = 0 for all scenarios offering an increase in *Reserve* area over the status quo;
*RESDIFF*LOSS*VRONLY*	Interaction term. Equals *RESDIFF* for all scenarios where the alternative offers a reduction in *Reserve* area from the status quo and the respondent faced the *VR_ONLY* treatment; = 0 otherwise. Note that this variable is omitted from our model so that this becomes the base category treatment from which the departures of other treatments are calculated.
*RESDIFF*LOSS* VR&NUMERIC*	Interaction term. Equals *RESDIFF* for all scenarios where the alternative offers a reduction in *Reserve* area from the status quo and the respondent faced the *VR&NUMERIC* treatment; = 0 otherwise.
*RESDIFF*LOSS*NUMERIC_ONLY*	Interaction term. Equals *RESDIFF* for all scenarios where the alternative offers a reduction in *Reserve* area from the status quo and the respondent faced the *NUMERIC_ONLY* treatment; = 0 otherwise.
*RESDIFF*GAIN*	Interaction term
*RESDIFF*GAIN*VRONLY*	Interaction term
*RESDIFF*GAIN* VR&NUMERIC*	Interaction term
*RESDIFF*GAIN*NUMERIC_ONLY*	Interaction term
*FLOODDIF*LOSS*	Interaction term
*FLOODDIF*LOSS*VRONLY*	Interaction term
*FLOODDIF*LOSS* VR&NUMERIC*	Interaction term
*FLOODDIF*LOSS*NUMERIC_ONLY*	Interaction term
*FLOODDIF*GAIN*	Interaction term
*FLOODDIF*GAIN*VRONLY*	Interaction term

*FLOODDIF*GAIN* VR&NUMERIC*	Interaction term
*FLOODDIF*GAIN*NUMERIC_ONLY*	Interaction term
OVERSEAS	= 1 if the respondent generally lived overseas and therefore was liable to pay for the good in question for a shorter period of time than other respondents; = 0 otherwise.
*COST*OVERSEAS*	Interaction term
CONSTANT	Constant
σ_{u0}^2	Intra-respondent variation

In conducting econometric analysis of this data, we chose to pursue a parsimonious design focussing on the central issues of interest to our hypothesis testing. In particular we are interested in examining whether different modes of information provision lead to differing degrees of loss aversion and hence gains/loss asymmetry. Therefore an approach which distinguished WTP for gains from EL for avoiding losses was required. Within the latter we also required examinations of any interactions between information treatments and implicit EL values. Further testing indicated that other effects, such as those associated with respondents socio-economic and gender circumstances, could be kept to a minimum[17] (with some minor exceptions, discussed subsequently). Given the straightforward nature of the SQ+1 design, a simple random effects logit model (Goldstein, 1995) applied to differences in attribute levels from the status quo (rather than their absolute level as per the multinomial logit model) was sufficient to ensure consistency with a random utility model of preferences.

Initial analysis[18] estimated a fully unconstrained model. This included the COST variable alongside the two land-use attributes *RESDIFF* and *FLOODDIF.* For these latter attributes, interaction terms allowed identification of any difference in response patterns within either the gain or loss dimension. Furthermore, within each of these dimension further interaction terms allowed the identification of any effects due to the various information treatments (i.e. *VR_ONLY*, *NUMERIC_ONLY* and *VR&NUMERIC*) used in our study design. This analysis allowed the response to gains in the area of both *Reserve* and *Flooded* land to differ from that to losses and for this effect to be dependent upon the survey treatment each user experienced. Results from this model indicated that respondents were more concerned about changes in *Reserve* area than in *Flooded* land. This model also contained a number of parameters which did not reach statistical significance, namely all treatment interactions (in both the gain and loss dimension) with the *FLOODDIF* variable and treatment interactions in the gain dimension for the *RESDIFF* variable.

In order to examine which variables might be removed and hence derive a parsimonious model of our data, we systematically tested constraints that coefficients on treatment effects (*VR_ONLY*, *NUMERIC_ONLY* and *VR&NUMERIC*) and gain/loss effects were equal. Standard likelihood ratio (LR) tests indicated that we could not reject the constraint that for the *FLOODDIF* variable, both the treatment effects and any gains/loss asymmetry were insignificant[19]. This may well reflect the relatively weak preferences regarding *Flooded* land.

[17] Given the relative homogeneity of our student-based sample this is hardly surprising. Further effects might be expected within a more diverse sample but these are not of relevance to the issues under investigation here.

[18] Although we describe a top-down model building approach here, the same best-fit model was also arrived at by using bottom-up techniques.

[19] Although statistically insignificant, after constraining treatment effects to be equal, the weak gains/loss asymmetry associated with *Flooded* land is nonetheless interesting. While the underlying effect for *FLOODDIF* was negative when all interactions were omitted (i.e. individuals see increases in flooded area as generating disutility), the *FLOODDIF*LOSS* interaction is both positive and of sufficient size that, if it were significant, it would suggest that respondents also see losses as undesirable. In effect this would suggest an extreme

By contrast respondents exhibited strong preferences regarding *Reserve* area with strong gains/loss asymmetry. Analysis showed that we cannot reject the constraint that treatment effects are equivalent for changes in the gain dimension for *Reserve* area. Comparing likelihood estimates[20], the initial unconstrained model (containing all treatment and gain/loss interactions) did not provide a superior fit to the model derived through the above constraints (χ^2 = 2.11, df = 7, p = 0.95). However, further testing of a fully constrained model rejected the hypothesis that we can constrain to be equal the treatment effects in the loss dimension of *Reserve* area (χ^2 = 37.91, df = 10, p < 0.01). These various constraints result in the final restricted model as detailed in Table 2.

Table 2: Random effects logit model parameter estimates (*VR_ONLY* treatment taken as the base treatment category for losses)

Parameter	β	s.e.	t	Wald[21]
CONSTANT	0.0241	0.1241	0.19	0.038
OVERSEAS	0.4005	0.1319	3.04	9.214*
COST	-0.03566	0.003332	-10.70	114.554*
FLOODDIF	-0.001431	0.000679	-2.11	4.448*
RESDIFF	0.005669	0.002183	2.60	6.744*
*RESDIFF*LOSS*	0.01170	0.003629	3.22	45.062*
*RESDIFF*LOSS* VR&NUMERIC*	0.002468	0.002295	1.08	1.156
*RESDIFF*LOSS*NUMERIC_ONLY*	0.01613	0.002826	5.71	32.591*
σ^2_{u0} †	0.837	0.099	8.45	

Notes: * = Significant at p<0.05

† = Random (hierarchical) effects; intra-respondent variation[22]. Level 1 (choice) variance (σ^2_{e0}) constrained to 1.

The model detailed in Table 2 provides a variety of insights into respondents' preferences as well as providing results necessary to test our null hypothesis. Working through the model estimates, the intercept is insignificant, as per expectations for such a model[23]. Given the general homogeneity of our sample and the focus of our experiment we have only included one, highly significant, personal characteristic effect as captured in the *OVERSEAS*

endowment point effect where any move away from the status quo lowers utility. Note that if we were to relax our significance criteria to p<0.1 then the *FLOODDIF*LOSS* interaction would just prove significant (t = 1.69; p = 0.0916). Other, treatment related, interactions were more clearly insignificant.

[20] Values are as follows: Fully unconstrained model (with all interactions), 2*LL = 4348.44 (df = 15); 'Best-fit' model (as shown in Table 2 of this paper), 2*LL = 4350.55 (df = 8); Fully constrained model (with no interactions), 2*LL = 4386.35 (df = 5). In addition to the tests reported in the main body of this paper we also reject the additional constraints involved in a move from the 'best-fit' to 'fully constrained' model (χ^2 = 35.80, df = 3, p < 0.01)

[21] The Wald statistic is used for testing significance in logistic models. It follows the chi-squared distribution with each Wald statistic analogous to a chi-square value with 1 degree of freedom. The square root of the Wald statistic gives the t-ratio.

[22] The model shows significant intra-respondent variation; a common finding in valuation studies. See, for example, the meta analysis of valuation studies reported by Bateman and Jones (2003).

[23] This is the expectation given the set up of the model. For example, a significant positive constant would indicate some inexplicable tendency for respondents to always prefer the future scenario. However, the constant is very clearly insignificant.

variable[24]. This shows that respondents who typically reside overseas and therefore would only pay for the good in question for a relatively short period are more likely to choose the alternative option. Such a finding accords with prior empirical work indicating that those that do not have to bear the cost of such schemes nevertheless often seem quite prepared to impose expenditures upon others in return for an increase in public goods provision (Bateman et al., 2003).

Turning to consider the first attribute of the choice set, the relationship with the *COST* of alternatives to the status quo is, as expected, negative and is the most strongly significant of all effects; as the cost of an alternative option increases so respondents are less likely to choose that option.

The *FLOODDIF* variable yields significant scope sensitivity although the relatively small size of the estimated coefficient, which is directly comparable to that on *RESDIFF*, shows that preferences for changes in *Flooded* area are much weaker than those for nature reserve. Furthermore, the negative estimated coefficient on *FLOODDIF* shows that respondents see additional *Flooded* areas as constituting a loss of utility[25].

The positive, relatively large and highly significant coefficient estimated for the *RESDIFF* variable is as expected. Due to the specification of the (subsequently discussed) interaction terms in the model, this coefficient shows the net effect of gains in freshwater reserve over the status quo. Comparing the estimated coefficient with that for *COST* gives a marginal WTP value of roughly £0.16 for a one hectare gain over the status quo.

The next three variables, all of them interaction terms (*RESDIFF*LOSS*, *RESDIFF*LOSS*VR&NUMERIC* and *RESDIFF*LOSS*NUMERIC_ONLY*), constitute the major focus of our analysis, allowing us not only to inspect the degree of gains/loss asymmetry but also examine the extent to which this varies across presentation treatments and hence test our null hypothesis. The *RESDIFF*LOSS* interaction allows us to examine the extent to which marginal EL values (for avoiding losses in *Reserve* area) differ from marginal WTP values (for gains in *Reserve*). Furthermore, because of the inclusion of the two triple interaction terms (*RESDIFF*LOSS*VR&NUMERIC* and *RESDIFF*LOSS*NUMERIC_ONLY*) within the model, the *RESDIFF*LOSS* interaction tells us about the base case treatment, here specified as being respondents who were only presented with the VR visual information concerning changes in land use (the *VR_ONLY* treatment). Here the positive and highly significant coefficient on the *RESDIFF*LOSS* interaction indicates a much higher marginal value for avoiding losses of *Reserve* than was the case for gains; i.e. we observe strong gains/loss asymmetry. Adding this interaction to the underlying relationship (given by the *RESDIFF* coefficient) and dividing by the *COST* coefficient gives a marginal EL value of just under £0.50 to avoid the loss of a hectare of *Reserve*. Contrasting this with the marginal value for gains allows us to calculate our first EL/WTP ratio which, for the *VR_ONLY* treatment is 3.1. This is somewhat higher than the range of EL/WTP ratios obtained from Bateman et al., (1997) which varied from just over one to about 2.8. However, the latter study examined a range of highly familiar, high consumption, private goods (chocolates, Coke and money) whereas the present study looks

[24] Analysis of how best to incorporate the effect of overseas respondents was undertaken. This showed that a model incorporating just the main effect variable, *OVERSEAS*, fitted the data significantly better than either a model substituting this for the interaction term *COST*OVERSEAS* or a model incorporating both of these variables.

[25] While the disutility associated with additional *Flooded* areas is hardly surprising, nevertheless from an ecological perspective such areas are of high biodiversity habitat value. This seems to demonstrate a commonly asserted problem of preference based decision systems; most individuals do not like muddy saltmarsh areas and are either unaware or do not care about the creatures that live there. The fact that such creatures frequently form a vital link in biodiversity support systems is not one readily appreciated by the typical individual.

at less familiar, low consumption, public good. The increase in EL/WTP ratio seems entirely in keeping with the general findings of Horowitz and McConnell (2002) who link higher levels of gains/loss asymmetry with less familiar, less 'ordinary' goods. However, again in line with prior expectations, the EL/WTP ratios found in the present study are considerably lower than the WTA/WTP ratios for similar non-market goods noted by Horowitz and McConnell[26]. Of more interest to the present paper is to contrast this finding with asymmetry ratios for the other presentation treatments; to which we now turn.

The departure of the *VR&NUMERIC* treatment from the base case for losses (the *VR_ONLY* treatment discussed above) is indicated by the *RESDIFF*LOSS* VR&NUMERIC* coefficient. As can be seen in Table 2, the estimated coefficient is positive indicating that the addition of numeric to visual information causes an increase in the gains/loss anomaly compared to the base case. This is an interesting finding as it fits with the expectations of the evaluability argument for a case where numeric information is not well comprehended by respondents and instead acts as a heuristic (gains/loss) cue. This increase in asymmetry results in a rise in the marginal EL value for preventing a loss of *Reserve* to just over £0.50, increasing the EL/WTP ratio to roughly 3.5. However, the estimated coefficient on the *RESDIFF*LOSS*VR&NUMERIC* variable is not statistically significant indicating that for the comparison between the *VR_ONLY* and *VR&NUMERIC* treatments we cannot reject the null hypothesis of no difference in the resulting degree of gains/loss asymmetry. It seems that, providing respondents are presented with visual information, the additional provision of numerical information does not significantly affect the degree to which the gains/loss asymmetry anomaly occurs. This seems entirely plausible. However, our key test is the contrast with respondents facing the standard CE format of numeric information provision alone and it is to that which we now turn.

The *RESDIFF*LOSS*NUMERIC_ONLY* variable indicates the departure of those respondents who received only numeric information from the base case of respondents who saw both numeric and visual information. As can been seen from the results of Table 2, the former group expressed preferences which were strongly significantly different from those facing the base *VR_ONLY* treatment. Further testing of an alternative model in which the base group is respecified as the *VR&NUMERIC* treatment showed that the difference between this and the *NUMERIC_ONLY* treatment was also significant ($p<0.05$). These tests and the comparatively very large departure estimated in the *RESDIFF*LOST*NUMERIC_ONLY* coefficient indicates a much stronger loss aversion and hence great gains/loss asymmetry amongst respondents presented with numeric information only than amongst those who were either additionally or exclusively presented with visual information. Marginal EL values for the former group were the highest at £0.94 per hectare, a value nearly twice that obtained from the other treatments and implying an EL/WTP ration of nearly 6.0. Consequently we very clearly reject our null hypothesis for comparisons between respondents in the numeric only treatment and those presented with visual information. Net effects, marginal values, gain/loss asymmetry ratios and hypothesis test results are summarised in Table 3.

[26] Horowitz and McConnell report a mean WTA/WTP ratio for public or non-market goods in excess of 10. That the ratios reported throughout our paper are considerably lower than this is to be expected. While Horowitz and McConnell focus on the WTA/WTP ratio, we examine EL/WTP ratios which both theory and empirical investigation suggest will be substantially smaller than the former (Tversky and Kahneman, 1991; Bateman et al., 1997). A further reason may be related to a methodological switch between the CV studies examined by Horowitz and McConnell and the CE approached used here. However, we are unaware of controlled methodological comparisons of gains/loss asymmetry rates across CV and CE studies.

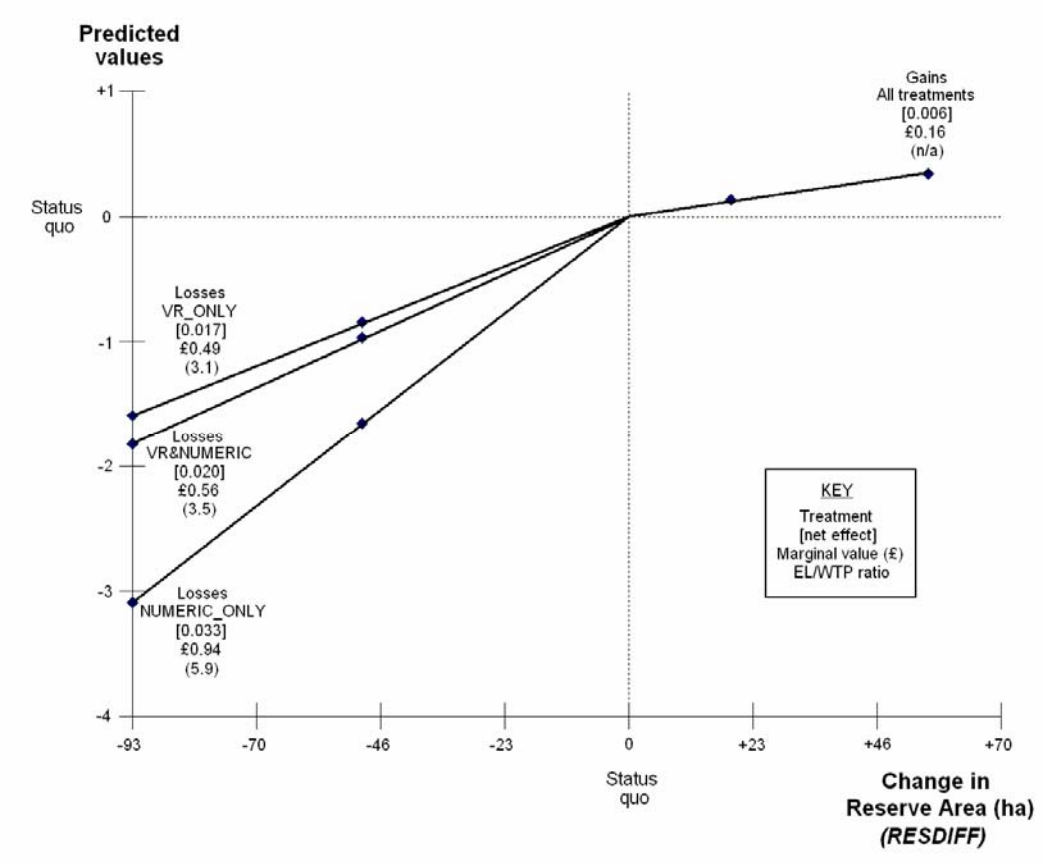
Table 3: Marginal WTP values and loss/gain asymmetry ratios across the three information provision treatments

Change in *Reserve*	Information provision treatment	Net effect	Marginal value[1]	loss/gain ratio	Hypothesis test results
Gains	All treatments	*RESDIFF* = 0.005669	£ 0.1589	n/a	-
Losses	*VR_ONLY*	*RESDIFF* + *RESDIFF*LOSS* = 0.005669 + 0.01170 = 0.017369	£ 0.4871	3.07	Reject H_o for comparison against *NUMERIC_ONLY* but not against *VR&NUMERIC*
Losses	*VR&NUMERIC*	*RESDIFF* + *RESDIFF*LOSS* + *RESDIFF*LOSS * VR&NUMERIC* = 0.005669 + 0.01170 + 0.002468 = 0.019837	£ 0.5563	3.50	Reject H_o for comparison against *NUMERIC_ONLY* but not against *VR_ONLY*
Losses	*NUMERIC_ONLY*	*RESDIFF* + *RESDIFF*LOSS* + *RESDIFF*LOSS * NUMERIC_ONLY* = 0.005669 + 0.01170 + 0.01613 = 0.033499	£ 0.9394	5.91	Reject H_o for comparison against *VR_ONLY* and against *VR&NUMERIC*

Notes: 1. WTP for gains or EL for losses. Calculated as the net effect divided by the absolute value of the *COST* coefficient (i.e. 0.03566).

Given the central thesis of this study it seems only appropriate to illustrate these principal results visually, as per Figure 3. This graphically demonstrates the differences in gain/loss asymmetry across the various information provision treatments.

Figure 3: Estimated gain/loss asymmetries for changes in the area of nature reserve as evaluated under three information provision treatments



4. DISCUSSION AND CONCLUSIONS

In their review, Horowitz and McConnell (2002) show that gains/loss asymmetry is a highly significant and pervasive feature of both the non-market valuation and experimental economic literatures. Its prevalence has fuelled a strong theoretical debate regarding whether or not empirical results are compatible with standard theory or support non-standard perspectives such as loss aversion and its relation to reference dependent utility theory.

While it seems likely to the authors that both standard and non-standard perspectives have valuable insights to offer, the present paper does not attempt to discriminate between these competing theories. Rather we examine the possibility that, within non-market valuation studies, certain forms of information provision, specifically those which rely heavily upon the use of numeric information, may lack what psychologists have termed 'evaluability'. This, we argue, exacerbates tendencies for respondents to rely upon heuristic cues in answering survey questions. In particular, such survey approaches may lead respondents to view changes in attributes not in terms of their prima-facie continuous levels of provision, but rather in more discrete gain vs. loss terms.

Our results show that reliance upon numeric information alone does indeed lead to significant increases in gains/loss asymmetry. This suggests that, in this case, such forms of information provision have increased reliance upon the loss aversion heuristic and lead to increasingly anomalous results. It may very well be that the strength of such effects varies

according to the nature of the good under investigation and that, in a manner resonant of the findings of Horowitz and McConnell, the less a good is like an ‘‘ordinary market good’’ then the higher is the potential for evaluability problems. Indeed it is tempting to conclude that the evaluability problem may in part explain the very steep increase in gains/loss asymmetry noted by those authors as they move from considering money trades and private goods to assessments of non-market and public goods.

However, our research also has a hopeful message, even for the valuation of non-market goods. The new, VR based, approach to CE valuations which we develop through this paper offers a method of directly addressing the evaluability problems of certain numeric information (particularly regarding changes in the provision of environmental goods). By linking VR technology through to GIS databases, realistic, accurate and evaluable representations of real world environments can be generated. Furthermore, once generated, such virtual environments are readily employed in either the laboratory or field. We believe that such innovations may allow a leap forward in non-market valuation techniques, permitting researchers to convey realistic policy change scenarios in a manner which, as we demonstrate in the present study, directly reduces reliance upon response heuristics and consequent anomalies and thereby allowing underlying preferences to be more effectively measured.

References

Adamowicz W.L., Louviere, J.J. and Williams, M. (1994) Combining stated and revealed preference methods for valuing environmental amenities, *Journal of Environmental Economics and Management*, 26: 271-292.

Adamowicz, W.,L., Swait, J., Boxall, P., Louviere, J., and Williams, M. (1997) Perceptions versus Objective Measures of Environmental Quality in Combined Revealed and Stated Preference Models of Environmental Valuation, *Journal of Environmental Economics and Management*. (32):65-84.

Adamowicz, W., Boxall, P., Williams, M., Louviere, J. (1998) Stated preference approaches for measuring passive use values: choice experiments and contingent valuation, *American Journal of Agricultural Economics,* 80(1): 64-75.

Adamowicz W.L., Boxall, P., Louviere, J.J., Swait, J. and Williams, M. (1999) Stated preference methods for valuing environmental amenities, in Bateman, I.J. and Willis, K.G. (eds.) *Valuing Environmental Preferences: Theory and Practice of the Contingent Valuation Method in the US, EU and Developing Countries*, Oxford University Press, Oxford, 460-479.

Appleton, Katie J. and Lovett, Andrew A. (2003) GIS-based visualisation of rural landscapes: defining 'sufficient' realism for environmental decision making, *Landscape and Urban Planning*, 65, 117-131.

Appleton, Katie J. and Lovett, Andrew A. (2005) GIS-based visualisation of development proposals: reactions from planning and related professionals, *Computers, Environment and Urban Systems*, 29, 321-339.

Ariely, Dan, Loewenstein, George and Prelec, Dražen (2003) "Coherent arbitrariness": Stable demand curves without stable preferences, *Quarterly Journal of Economics,* 118(1): 73-105.

Bateman, Ian J., Carson, Richard T., Day, Brett, Hanemann, W. Michael, Hanley, Nick, Hett, Tannis, Jones-Lee, Michael, Loomes, Graham, Mourato, Susana, Özdemiroğlu, Ece, Pearce, David W., Sugden, Robert and Swanson, John (2002) *Economic Valuation with Stated Preference Techniques: A Manual*, Edward Elgar Publishing, Cheltenham.

Bateman, Ian J., Day, B.H., Dupont, D. and Georgiou, S. (2004) OOH la la: Testing the one-and-one-half bound dichotomous choice elicitation method for robustness to anomalies. *CSERGE Working Paper EDM 04-06,* Centre for Social and Economic Research on the Global Environment, University of East Anglia.

Bateman, Ian J. and Jones, Andrew P., (2003) Contrasting conventional with multi-level modelling approaches to meta-analysis: An illustration using UK woodland recreation values, *Land Economics*, 79(2): 235-258.

Bateman, Ian J., Ian H. Langford, R. Kerry Turner, Kenneth G. Willis and Guy D. Garrod (1995), Elicitation and truncation effects in contingent valuation studies, *Ecological Economics*, 12(2):161-179.

Bateman, Ian J., Ian H. Langford, Andrew P. Jones and Geoff N. Kerr, 2001, Bound and path effects in multiple-bound dichotomous choice contingent valuation, *Resource and Energy Economics*, 23(3): 191-213.

Bateman, Ian J., Lovett, Andrew A. and Brainard, Julii S. (2003) *Applied Environmental Economics: a GIS Approach to Cost-Benefit Analysis,* Cambridge University Press, Cambridge.

Bateman, Ian J., Munro, A., Rhodes, B., Starmer, C. and Sugden, R. (1997) A test of the theory of reference-dependent preferences, *Quarterly Journal of Economics,* 112(2): 479-505.

Bateman, Ian J., Langford, I.H., Munro, A., Starmer, C. and Sugden, R. (2000) Estimating the four Hicksian measures for a public good: a contingent valuation investigation, *Land Economics*, 76(3): 355-373.

Bateman, I.J., Turner, R.K., Klein, R.J.T., and Langford, I.H. (2001) The Application of the Cost Benefit Method to Sea Defence and Coastal Protection Management in England. p.113-142. In Turner, R.K., Bateman, I.J. and Adger, W.M. (eds.) *Economics of Coastal*

and Water Resources: Valuing Environmental Functions. Kluwer Academic. Dordrecht. 342pp.

Bennett, J. and Blamey, R. (Eds). (2001) *The Choice Modelling Approach to Environmental Valuation*, Edward Elgar, Cheltenham.

Berrens, R. P., Bohara, A.K., Silva, C.L., Brookshire, D., and McKee, M. (2000) Contingent values for New Mexico instream flows: With tests of scope, group-size reminder and temporal reliability, *Journal of Environmental Management*, 58(1) 73-90.

Binmore, Kenneth, 1994, *Playing Fair*, MIT Press.

Binmore, Kenneth, 1999, Why Experiment in Economics?, *The Economic Journal* 109, F16-F24.

Bishop, I. D., Ye, W.-S., Karadaglis, C. (2001), Experiential approaches to perception response in virtual worlds. Landscape and Urban Planning, 54: 115-123.

Blamey, R., Bennett, J., Louviere, J., Morrison, M. and Rolfe, R. (2002). Attribute Causality in Environmental Choice Modelling. *Environmental and Resource Economics*. 23: 167-186.

Boxall, P.C., Adamowicz, W.L., Swait, J., Williams, M., Louviere, J. (1996) A comparison of stated preference methods for environmental valuation, Ecological Economics, 18(3): 243-253

Braga, Jacinto and Chris Starmer, (2005) Preference anomalies, preference elicitation and the discovered preference hypothesis, *Environmental and Resource Economics*, 32, 55-89.

Bullock, C.H., Elston, D.A., Chalmers, N.A. (1998) An application of economic choice experiments to a traditional land use: deer hunting and landscape change in the Scottish Highlands, *Journal of Environmental Management*, 52(4): 335-351

Burton Anthony, C., Kate S. Carson, Sue M. Chilton and W. George Hutchinson, 2001, Are Hypothetical Referenda Incentive Compatible? Paper Presented at the Association of Environmental and Resource Economists (AERE) Sessions at the *Allied Social Science Association Annual Conference*, New Orleans, Louisiana, January 2001.

Camerer, Colin F., (2003) *Behavioral Game Theory* (Princeton: Princeton University Press.

Cameron, Trudy .A. and John Quiggin, 1994, Estimation using contingent valuation data from a "dichotomous choice with follow-up" questionnaire, *Journal of Environmental Economics and Management*, 27, 218-234.

Carson, Richard T. (forthcoming), *Contingent Valuation: A Comprehensive Bibliography and History*. Northampton, MA: Edward Elgar.

Carson, Richard T., Theodore Groves and Mark J. Machina, 1999, Incentive and informational properties of preference questions, Plenary Address, *Ninth Annual Conference of the European Association of Environmental and Resource Economists* (EAERE), Oslo, Norway, June 1999.

Champ, Patricia, Kevin Boyle and Thomas C. Brown (2003) *A Primer on Nonmarket Valuation*, Kluwer Academic Publishers, Dordrecht.

Cooper, David J., Kagel, John H., Lo, Wei and Gu, Qing Liang, (1999) Gaming Against Managers in Incentive Systems: Experimental Results with Chinese Students and Chinese Managers, *American Economic Review*, 89(4), 781-804.

Cummings, Ronald G., S. Elliott, Glenn W. Harrison and J. Murphy, 1997, Are Hypothetical Referenda Incentive Compatible? *Journal of Political Economy*, 105(3): 609-621.

Cummings, Ronald G, Harrison, Glenn W and Rutström, E. Elisabet, (1995) Homegrown Values and Hypothetical Surveys: Is the Dichotomous Choice Approach Incentive-Compatible?, *American Economic Review*, 85(1): 260-66.

Davies, A., Laing, R.A., and Macmillan, D.C. (2000) The use of choice experiments in the built environment: an innovative approach. *Proceedings of Transitions Towards a Sustainable Europe: Ecology, Economy, Policy. Third Biennial Conference of the European Society for Ecological Economics, Vienna*.

Davies, A., Laing, R., and Scott, S. (2002) Combining visualisation and choice experiments in built environment research. *Proceedings of the 6th International Conference on Information Visualisation, London, 10-12th July, 2002*.

Diamond, Peter A. and Jerry A. Hausman, (1994) Contingent Valuation: Is Some Number better than No Number? *The Journal of Economic Perspectives*, 8(4): 45-64.

Duffield, J. W., T. C. Brown and S. D. Allen. (1994) Economic value of instream flow in Montana's Big Hole and Bitterroot Rivers, *USDA Forest Service Research Paper RM-317*, Rocky Mountain Forest & Range Experiment Station, Fort Collins, CO.

Eagly, A.H. and Chaiken, S. (1993) *The psychology of attitudes*, Harcourt Brace College Publishers.

EFTEC (2006) *Economic Valuation of Environmental Impacts in the Severely Disadvantaged Areas,* Department for Environment, Food and Rural Affairs, London.

Epley, Nicholas, and Thomas Gilovich, 2001, Putting Adjustment Back in the Anchoring and Adjustment Heuristic: Differential Processing of Self-Generated and Experimenter-Provided Anchors, *Psychological Science,* 12: 391–396.

Evans & Sutherland (2003), Home page (visualisation systems). http://www.es.com

Huang, B., Jiang, B., Li, H. (2001), An integration of GIS, virtual reality and the internet for visualization, analysis and exploration of spatial data. International Journal of GIS, 15 (5): 439-456

Fagerlin, Angela, Catharine Wang and Peter A. Ubel, (2005) Reducing the Influence of Anecdotal Reasoning on People's Health Care Decisions: Is a Picture Worth a Thousand Statistics? *Medical Decision Making*, 25:398–405.

Fukahori, K. and Kubota, Y. (2003) The role of design elements on the cost-effectiveness of streetscape improvement. *Landscape and Urban Planning*. 63. 75-91.

Goldstein, Harvey (1995) *Multilevel Statistical Models* (2nd edition), Edward Arnold, London.

Green, Donald, Karen E. Jacowitz, Daniel Kahneman and Daniel McFadden, 1998, Referendum contingent valuation, anchoring, and willingness to pay for public goods, *Resource and Energy Economics*, 20: 85-116.

Gregory, Robin, Lichtenstein, Sarah, and Slovic, Paul (1993). Valuing environmental resources: A constructive approach, *Journal of Risk and Uncertainty*, 7: 177-197.

Haab, Timothy C. and Kenneth E. McConnell, (2003) *Valuing Environmental and Natural Resources: The Econometrics of Non-Market Valuation*, Edward Elgar Publishers, Cheltenham.

Hanemann, W. Michael, (1991) Willingness to pay and willingness to accept: How much can they differ? *American Economic Review,* 81(3): 635-647.

Hanemann, W. Michael, (1999) The economic theory of WTP and WTA, *in* Ian Bateman and Kenneth G. Willis, (Eds.) Valuing Environmental Preferences: Theory and Practice of the Contingent Valuation Method in the US, EU, and Developing Countries, Oxford University Press, Oxford.

Hanley, N., Koop, G., Wright, R. and Alvarez-Farizo, B. (2001a) Go Climb a Mountain: An Application of Recreational Demand Models to Rock Climbing, *Journal of Agricultural Economics* 52(1): 36-51.

Hanley, N., MacMillan, D., Wright, R.E., Bullock, C., Simpson, I., Parsisson, D. and Crabtree, B. (1998) Contingent Valuation Versus Choice Experiments: Estimating the Benefits of Environmentally Sensitive Areas in Scotland. *Journal of Agricultural Economics*. 49 (1), 1-15.

Hanley, Nick, Mourato, Susana and Wright, Robert E, (2001b) Choice Modelling Approaches: A Superior Alternative for Environmental Valuation? *Journal of Economic Surveys*, vol. 15(3), pages 435-62.

Hanley, Nick, Douglas MacMillan, Ian Patterson and Robert E. Wright (2003) Economics and the design of nature conservation policy: a case study of wild goose conservation in Scotland using choice experiments, *Animal Conservation*, 6(2), 123-129.

Harris, C.C., Driver, B.L. and McLaughlin, M.J., 1989, Improving the contingent valuation method: a psychological approach, *Journal of Environmental Economics and Management*, 17:213-229.

Harrison, Glenn W, Stephen M Fiore, Charles E Hughes and Eduardo Salas (2005) Cognition in natural environments: Using simulated scenarios in complex decision

making, Proposal to the National Science Foundation, University of Central Florida, Orlando.
Harrison, Glenn W., and List, John A., "Naturally Occurring Markets and Exogenous Laboratory Experiments: A Case Study of the Winner's Curse," *Working Paper 3-14*, Department of Economics, College of Business Administration, University of Central Florida, 2003; http://www.bus.ucf.edu/wp/.
Harrison, Glenn W., and List, John A., "Field Experiments," *Journal of Economic Literature*, 42(4), December 2004, 1013-1059.
Hensher, David A., John M. Rose and William H. Greene (2005) *Applied Choice Analysis*, Cambridge University Press, Cambridge.
Hibbard JH, Slovic P, Peters EM, Finucane M. (2002) Strategies for Reporting Health Plan Performance Information to Consumers: Evidence from Controlled Studies. *Health Services Research*, 37(2): 291-313.
Hibbard J.H. and Peters E. (2003) Supporting Informed Consumer Health Care Decisions: Data presentation approaches that facilitate the use of information in choice. *Annual Review of Public Health.* Vol. 24: 413-433.
Hicks, J.R. (1943) The four consumer surpluses. *Review of Economic Studies* 8: 108-116.
Hoeffler, Steve and Dan Ariely, 1999, Constructing stable preferences: A look into dimensions of experience and their impact on preference stability, *Journal of Consumer Psychology*, 11: 113-139.
Holmes, T. and Adamowicz, W.L., (2003) Attribute-based methods, in Champ, P.A., Boyle, K. and Brown, T.C. (eds.) *A Primer on Non-market Valuation,* Kluwer Academic Press, Dordrecht.
Horowitz, John K. and Kenneth E. McConnell (2002) A Review of WTA / WTP Studies, *Journal of Environmental Economics and Management*, 44: 426-447.
Hsee, Chris, K. (1996a). Elastic justification: How unjustifiable factors influence judgments. *Organizational Behavior and Human Decision Processes*, 66, 122-129.
Hsee, Chris, K. (1996b). The evaluability hypothesis: An explanation for preference reversals between joint and separate evaluations of alternatives. *Organizational Behavior and Human Decision Processes*, 67, 242-257.
Hsee, Chris, K. (1998). Less is better; When low-value options are valued more highly than high-value options. *Journal of Behavioral Decision Making*, 11, 107-121.
Hu, W., W.L. Adamowicz, and M.M. Veeman (forthcoming) Labeling Context and Reference Point Effects in Models of Food Attribute Demand, *American Journal of Agricultural Economics*, in press.
Jacobs, M. (1997) Environmental valuation, deliberative democracy and public decision-making institutions, in Foster, J. (ed.), *Valuing Nature?* Routledge, London.
Jacowitz, Karen E., and Daniel Kahneman, 1995, "Measures of Anchoring in Estimation Tasks," *Personality and Social Psychology Bulletin,* 21: 1161–1166.
Johnson, A. (1996). 'It's good to Talk': The focus group and the sociological imagination. *The Sociological Review*, 517-538.
Johnson, Eric J., and David A. Schkade, 1989, Bias in utility assessments: Further evidence and explanations, *Management Science*, 35: 406-424.
Jude, S.R., Jones, A.P., and Andrews, J.E. (2004) Visualisation for Coastal Zone Management. In Bartlett, D.J. and Smith, J. (eds.) *GIS for Coastal Zone Management*. CRC Press. pp. 95-107.
Jude, S.R., Jones, A.P., Bateman, I.J. and Andrews, J.E. (2003) Developing Techniques to Visualise Future Coastal Landscapes. In Buhmann, E. and Ervin, S.M. (eds.) *Trends in Landscape Modeling*, Herbert Wichmann Verlag, Heidelberg, p.228-238.
Jude, S., Jones, A.P. and Bateman, I.J., (2005) Visualisation for valuation – investigating the potential role of virtual reality and visualisation techniques in the economic valuation of future landscape change. Presented at *Our Shared Landscape: Integrating Ecological, Socio-Economic and Aesthetic Aspects in Landscape Planning and Management*, Centro Stefano Franscini, Ascona, Switzerland, May 2nd-6th, 2005.

Kahneman, Daniel, 1986, Comments, in Cummings, Ronald G., David S. Brookshire and William D. Schulze (eds.) *Valuing Environmental Goods: A State of the Arts Assessment of the Contingent Method*, Rowman and Allanheld, Totowa, N.J.

Kahneman, Daniel, Knetsch, Jack L. and Thaler, Richard H. (1991) Anomalies: The Endowment Effect, Loss Aversion, and Status Quo Bias, *Journal of Economic Perspectives*, 5(1): 193-206.

Kahneman, D., Ritov, I., and Schkade, D. (1999). Economic preferences or attitude expressions? An analysis of dollar responses to public issues. *Journal of Risk and Uncertainty*, 19, 220-242.

Kahneman, Daniel, Paul Slovic and Amos Tversky (1982) *Judgement Under Uncertainty: Heuristics and Biases*, Cambridge University Press, New York.

Kahneman, Daniel and Amos Tversky, 1982. The psychology of preferences, *Scientific American*, 246(1):160-173.

Laing, R., Davies, A., Hargreaves, A., and Scott, S. (2002) The application of 3D modelling techniques in built environment evaluation. In. *Proceedings of the Third International Conference on Decision Making in Environmental and Civil Engineering*. UCL, London, November 2002

Lancaster, Kelvin J. (1966) A New Approach to Consumer Theory, *Journal of Political Economy*, 74(2):132-157.

Lindberg, Kreg and Peter Fredman (2004) Destination Attributes and Predicted Market Shares: A Choice Experiment of Snowmobilers and Cross-Country Skiers, *Working Paper WP 2004:02*, European Tourism Research Institute, Sweden.

Lipkus, Isaac M. and J. G. Hollands (1999) The Visual Communication of Risk, *Journal of the National Cancer Institute Monographs*, (25): 149-163

List, John A., 2003, Does market experience eliminate market anomalies?, *Quarterly Journal of Economics* (February): 41-72.

Loomis, John B., Katherine Quattlebaum, Thomas C. Brown and Susan J. Alexander (2003) Expanding Institutional Arrangements for Acquiring Water for Environmental Purposes: Transactions Evidence for the Western United States, *International Journal of Water Resources Development*. 19(1): 21-28.

Louviere, J, Hensher, D and Swait, J. (2000) *Stated Choice Methods: Analysis and Application*, Cambridge University Press, Cambridge.

Lovett, A.A., Herrmann, S., Appleton , K.J. and Winter, T. (2003) "Landscape modelling and visualisation for environmental planning in intensive agricultural areas", pp.114-122 in E. Buhmann and S. Ervin (eds.) *Trends in Landscape Modeling*, Herbert Wichmann Verlag, Heidelberg.

Lovett, A. A., Sünnenberg, G., Appleton, K., Dockerty, T., Dolman, P., Cobb, D., O'Riordan, T. (2002), The use of VRML in landscape visualisation. pp. 68-85 in Buhmann, E., Nothhelfer, U., Pietsch, M., (eds.) Trends in GIS and Virtualization in Environmental Planning and Design; proceedings at Anhalt University of Applied Sciences, 2002. Heidelberg: Wichmann

MacDonald, Darla Hatton, Mark Morrison and Mary Barnes (unpub) Willingness to Pay and Willingness to Accept Compensation for Changes in Urban Water Customer Service Standards, CSIRO Land & Water, Glen Osmond, South Australia.

MacGregor, Donald, G., & Slovic, Paul (1986). Graphic representation of judgmental information, *Human-Computer Interaction*, 2: 179-200.

Magat, W.A., J. Huber and K. Viscusi (2000) An Iterative Choice Approach to Valuing Clean Lakes, Rivers and Streams, *Journal of Risk and Uncertainty*, 21:1, 7-43.

Mallawaarachchi, T., Blamey, R.K., Morrison, M.D., Johnson, A.K.L. and Bennett, J.W., (2001) Community values for environmental protection in a cane farming catchment in Northern Australia: a choice modelling study, *Journal of Environmental Management*, 62, 301–316.

Mallawaarachchi, Thilak, Mark D. Morrison and Russell K. Blamey (2006) Choice modelling to determine the significance of environmental amenity and production alternatives in the

community value of peri-urban land: Sunshine Coast, Australia, *Land Use Policy,* Volume 23, Issue 3 , Pages 323-332.
Mambretti, I., Lange, E. and Schmid, W.A. (2005) Using Visualization for the Evaluation of Safety and Aesthetics Conflicts in Urban Parks. p.282-290 In Buhmann, E., Paar, P., Bishop, I.D. and Lange, E. (eds.) *Trends in Real-Time Landscape Visualization and Participation*. Herbert Wichmann Verlag, Heidelberg. 361pp.
MultiGen-Paradigm (2003), Home page (SiteBuilder3D, Vega, OpenFlight format) http://www.multigen.com
Nisbett, R.E. and Ross, L. (1980) *Human inference: strategies and shortcomings of social judgment*, Prentice-Hall, Englewood Cliffs, New Jersey.
Orasanu, J. and Connolly, T. (1993) The reinvention of decision making, in G. A. Klein, J. Orasanu, R. Calderwood, & C. E. Zsambok (Eds.), Decision making in action: Models and methods, Ablex Publishers, Norwood, NJ.
O'Riordan, T. Wood, C., and Shadrake, A. (1993) Landscapes for Tomorrow. *Journal of Environmental Planning and Management*. 36. (2). 123-147.
Peters, Ellen, Paul Slovic and Judith Hibbard (2005a) *Bringing Meaning to Numbers: Evaluability and Affect in Choice*, University of Oregon, Eugene, Oregon.
Peters, Ellen, Nathan Dieckmann, Daniel Västfjäll and C.K. Mertz (2005b) *When five out of four people have trouble with fractions and other numbers: Numeracy and mood in decisions*, University of Oregon, Eugene, Oregon.
Rabin, Matthew (1998) Psychology and Economics, *Journal of Economic Literature*, American Economic Association, vol. 36(1), pages 11-46.
Roberts, K.J., M.E. Thompson and P.W. Pawlyk, 1985, Contingent valuation of recreational diving at petroleum rigs, Gulf of Mexico, *Transactions of the American Fisheries Society*, 114:155-165.
Sagoff, M. (2004) *Price, Principle, and the Environment*, Cambridge University Press, Cambridge.
Schkade, D. A., & Kahneman, D., 1998, Does living in California make people happy? A focusing illusion in judgments of life satisfaction. *Psychological Science, 9*, 340-346.
SGI (2003), Home page (visualization systems). http://www.sgi.com/visualization/
Slovic, Paul (1995) The construction of preferences, *American Psychologist*, 50: 364-371.
Slovic, Paul, Melissa L. Finucane, Ellen Peters, and Donald G. MacGregor (2004) Risk as Analysis and Risk as Feelings: Some Thoughts about Affect, Reason, Risk, and Rationality, *Risk Analysis*, 24(2): 311-322.
Slovic, P., Finucane, M. L., Peters, E., & MacGregor, D. G. (2002). The affect heuristic. In T. Gilovich & D. Griffin & D. Kahneman (Eds.), *Heuristics and biases: The psychology of intuitive judgment* (pp. 397-420). New York: Cambridge University Press
Stock, C., Bishop, I. D. (2002), Immersive, interactive exploration of changing landscapes. International Environmental Modelling and Software Society Conference, Lugano, Switzerland, June 24-27
Strack, Fritz, and Thomas Mussweiler, 1997, "Explaining the Enigmatic Anchoring Effect: Mechanisms of Selective Accessibility," *Journal of Personality and Social Psychology,* 73: 437–446.
Sugden, Robert (1999) Alternatives to the neo-classical theory of choice, *in* Ian Bateman and Kenneth G. Willis, (Eds.) Valuing Environmental Preferences: Theory and Practice of the Contingent Valuation Method in the US, EU, and Developing Countries, Oxford University Press, Oxford.
Taylor, Laura O., M. McKee, S.K. Laury and R.G. Cummings, 2001, Induced Value Tests of the Referendum Voting Mechanism, *Economic Letters*, 71(1): 61-6.
Terrex (2003), Home page (Terra Vista). http://www.terrex.com
Tversky, Amos and Daniel Kahneman (1974) Judgement under uncertainty: Heuristics and biases, *Science*, 185: 1124-1131.
Tversky, Amos and Daniel Kahneman, (1973) Availability: a heuristic for judging frequency and probability, *Cognitive Psychology*, 5, 207-232.

Tversky, Amos and Kahneman, Daniel (1991) Loss Aversion in Riskless Choice: A Reference-Dependent Model, *Quarterly Journal of Economics*, 106(4): 1039-1061.

Willis, K.G. and Garrod, G.D. (1992) Assessing the value of future landscapes. *Landscape and Urban Planning*. 23. 17-32.

Willis, K. G., and G. D. Garrod (1999) Angling and recreation values of low-flow alleviation in rivers, *Journal of Environmental Management* 57(2) 71-83.

Zavala, G., Pou, A. (2000) Preliminary results on realistic visualization of landscape changes in a small watershed in Urdaibai Biosphere Reserve (Basque Country, Spain). 6th EC-GI & GIS Workshop, The Spatial Information Society - Shaping the Future, Lyon, France, 28-30 June 2000. Also available at http://wwwlmu.jrc.it/Workshops/6ec-gis/papers/zavala-urdaibai.doc

Zikmund-Fisher, Brian J., Angela Fagerlin and Peter A. Ubel (2005) What's Time Got to Do with It? Inattention to Duration in Interpretation of Survival Graphs, *Risk Analysis*, Vol. 25, No. 3, pp589-595.