Combining visualisation and choice experiments in built environment research

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Abstract

This paper reports results from a project that combined the visualisation of streetscapes with environmental economics. The particular economic methodology employed was choice experimentation, which has previously tended to use text to convey scenarios between which respondents make choices. The research investigated how the visual impact of streetscapes could be incorporated in choice experiments through the use of 3-dimensional computer generated visualisations. Data was gathered initially through an Internet based survey, and replicated later using a high specification stand-alone machine. This paper identifies strengths and weaknesses in the approach, and reports results pertaining to effectiveness and practicality of the methodology. Using visualisation offers many potential benefits to the field of choice experimentation, and application within the built environment merits further development.

1: Introduction

Choice experimentation is a relatively new non-market valuation technique in which individuals choose their most preferred resource use option from a range of alternatives. Blamey et al. (1997) describe the technique as one in which individuals are typically presented with six to ten ‘choice sets’, each containing a base option and several alternatives, and asked to indicate their preferred option in each set. The base option generally corresponds to the current situation or ‘do nothing’ option that remains constant across all the choice sets. The attributes in each of the remaining choice set options are then varied to allow the researcher to estimate the relative importance of each attribute describing the option.

Choice experimentation attempts to identify the utility that individuals derive from the attributes of the commodity being valued. It does this by examining the trade-offs individuals make when making choice decisions. According to Hanley et al. (1998) researchers can infer four pieces of information from choice experiments. First, which attributes significantly influence choice; second, the implied ranking of these attributes; third, the marginal willingness to pay (WTP) for an increase in any significant attributes; and forth, implied WTP for a program which changes more than one attribute simultaneously.

To convey information, choice experiments describe a “choice set” using an array of attributes, rather than one specific change to the good or service. Rather than being questioned about a single event in detail, respondents are questioned about a sample of events drawn from the universe of possible events of that type (Louviere, 1994). Adamowicz et al. (1995) suggest that choice experiments may help therefore to reduce strategic bias as the attributes in each choice set change. Respondents will be unclear as to which situation is the most ‘environmentally friendly’ alternative and unable to vote for a particular situation because they believe it is the ‘right’ answer. In addition, choice experiments also eliminate the situation of respondents having to choose between paying for an environmental improvement or not paying for it.

Adamowicz et al. (1995) and Hanley et al. (1998) claim that because choice experiments are based on valuing attributes rather than a base case and an alternative, both specific attributes and situation changes can be valued. The experimental aspect of choice experiments, means that bundles of attributes can be constructed to reflect different states of the environmental good or service. Individuals are questioned on their preferred alternatives from the choice set, allowing the researcher to analyse the trade-offs made between attributes.
in the choice set. When price is included as one of the attributes, it becomes possible to estimate the economic values associated with the other attributes (Boxall et al. 1996). Furthermore, choice experiments allow compensation for damage to particular environmental goods and services to be in the form of other goods rather than strictly monetary terms (Adamowicz et al. 1995).

Finally, Adamowicz et al. (1995), Morrison et al. (1996) and Hanley et al. (1998) argue that the issue of embedding\(^1\), a commonly discussed problem in contingent valuation studies, is overcome through choice experimentation. As choice experiments are formed using varying levels of attributes, different subsets of goods (including substitutes) are essentially incorporated within their design. This enables researchers to determine an individual’s sensitivity to attribute levels thus eliminating embedding problems. Issues relating to specific attributes and substitutes can be explored prior to conducting the survey through the use of focus groups (Morrison et al. 1996).

A potential problem facing many quantitative methodologies is that of respondent burden. Where a research participant is required to simultaneously consider a complex range of variables, there is a danger that complexities in the real environment are lost on the respondent. Through the use of visual images, it was felt that there may be an opportunity to present a wide range of variables (e.g. lighting, setting, physical objects, spacing, perspective) in a way which was both easy to understand and which could act as a reasonable surrogate for possible but unbuilt “actual” environments.

Although environmental economics has been regarded as an established field within economics for many years, it is still true that the quantification of socio-economics impact is rarely attempted, in the UK at least (Chadwick 2002). The intention and main contribution of this research, rather to providing a one-stop solution to questions facing designers and planners of urban space, was to signal a method through which environmental economics might aid the design development process.

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1 Embedding effects occur ‘when the estimated mean willingness to pay for a good is lower when it is valued as part of a more inclusive good, rather than on its own’ (Morrison et al. 1996, p.12). Kahneman and Knetch (1992) provide a discussion of this form of bias.

2: Visualisation

Major questions posed by this research concerned the extent to which visual representations of a space could be used effectively within a choice experiment. Although it is true that many aspects of a space are non-visual to some extent (e.g. temperature, noise), it is also true that a number of prominent recent urban design guides focus very much on making physical changes to space. The methodology, therefore, took as its starting point a decision to impose a cultural scenario on the case study space, within which changes would be made.

A case study area within Aberdeen was selected for study. The area was of interest within the research as it arguably suffers from under investment, despite possessing great architectural and historical value. A series of focus groups was completed, including meetings with local residents, general public, design students and built environment professionals. The main purpose of these meetings was to identify possible uses for the case study area, and to suggest possible choices that might be faced by the designer and user alike.

A major finding from the focus groups was that participants generally responded more favourably towards options for the area which reflected a change of use, rather than simply considering individual objects. For example, respondents rarely suggested the planting of new tree species in the absence of a strong rationale. Rather, an emphasis was placed on the social environment, or the impact of physical changes on behaviour. For example, bollards could be used to create feelings of enclosure or openness; trees could be used to draw attention towards certain buildings, or to create a market space; benches and café seating could be used to significantly alter the desired amount of activity in the space.

From these focus groups, a number of possible arrangements for the space were designed, using various combinations of railings, café seating, trees and planters, benches, paving and lighting. The resulting proposed designs were then modelled in AutoCAD, producing a total of 18 unique configurations. Following further modelling and rendering work in 3D Studio Max, a series of high quality visual images were produced for use in the choice experiments. For each image, clear details were recorded as to the environment being shown, and the configuration for each of the variable objects. Sample images from the model are shown in Figure 1.
The methodology was also concerned with use of the internet to gather data in a choice experiment. This in itself began to limit the extent to which full virtual environments could be made available within experiments, notwithstanding concerns over the subsequent analysis of data. Pedestrians most easily approach the case study area from two main locations, these being located at a pedestrian entrance toward the south-west corner, and at the exit from a car park at the north-east.

3: Experimental work

3.1: Methodology

The experiment was completed in two stages, where the main differences were concerned with delivery of the material and control over the technology. The first phase of the study was implemented through an entirely Internet based experiment2. Following that study, the experiment was replicated on a high-end stand-alone machine, thus providing further data to the study as a whole, and also allowing for a comparison between the two forms of data transfer.

The research was particularly interested in any concerns over download time, image quality, and operation of various browsers types over the Internet. For example, in order to minimise download times, initially large images were necessarily reduced in size. Although the option was provided to view all images at a larger resolution, doing so inevitably increased the time required completing the questions. In addition, the researchers had no control over the size of screen used by respondents, so although it was possible to ensure compatibility with most browsers, the survey’s final appearance was more difficult to control.

3.2: Respondent comments

As part of the study, several open-ended questions were included at the end of the choice experiment to give respondents the opportunity to make any comments regarding the study, as well as provide feedback. Questions were asked about image quality, payment levels, ease of answering the questions, and the overall quality of the study. Responses from both the Internet and stand-alone studies were categorised and the results are discussed.

3.3 Results 1 (Internet study)

A total of 165 responses were received for the Internet-based study, and the three most common comments related to the images themselves.

19% of respondents stated that the images were too similar and found it difficult to tell the differences between them. 15% thought that the images were too small, and 15% thought the images were too dark. These comments suggest that many respondents only looked at the smaller images presented on the screen, and did not open them up to their full size. By opening up the larger images, respondents would have been able to see differences more clearly. The size of the images may also have affected brightness; that is, the smaller the image, the darker it will appear. If respondents had had opened up the larger images, they should have automatically appeared brighter. Alternatively, this problem may simply have been the result of respondents not adjusting their monitors at the beginning of the study3.

The fourth most common comment (made by 10% of respondents) was that more details regarding each option were needed. By providing some details about the attributes and levels displayed in each option, respondents would have been able to see the differences in each one more clearly. This may additionally have reduced the number of respondents claiming the images were too similar.

A range of comments was made regarding the types and levels information provided. For example, respondents wanted to know about the activities taking place in the square and uses of the surrounding area (2%), as well as the history of the Castlegate and the types of materials being used (5%).

The cost variable raised interest from respondents, in that each option was attached to a corresponding tax levy. Almost 7% of respondents said the suggested costs were too high and that they would not pay. However, almost as many respondents (6%) thought that the levels of cost were reasonable. Almost 4% of respondents said that cost did not influence their choices, although 4% would have liked a better explanation of this variable.

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2 The full study can be accessed via www2.rgu.ac.uk/subj/cps/exper/index.htm

3 A test image was included in the introduction and respondents were asked to adjust their monitors to optimise brightness and contrast.
Several other comments were made including:

- any costs would be difficult to administer;
- costs should be proportional to Council tax;
- the payment method proposed was an interesting one.

Almost 7% of respondents said that the survey was a good length\(^4\), however almost 4% thought that it was too long. Just under 4% of respondents said they liked the survey and/or thought it was interesting. An equal amount of respondents however thought the survey was confusing and were unclear about what they were doing.

\section*{3.4: Results 2 (stand alone study)}

While the stand-alone study was asking essentially the same questions as the Internet-based study, several improvements were made to the questionnaire based on an early analysis the Internet comments discussed above.

The main differences between the Internet and the stand-alone studies were the sizes of the images presented to respondents and amount of information provided. The stand-alone study was conducted on one stand-alone computer, which made it easier to control some of the problems that occurred in the Internet study. For example, issues to do with individual monitors (such as screen size and brightness) were virtually eliminated. All respondents from the Stand-alone study viewed the study on same monitor (a high quality 21-inch screen) and saw the images at the same level of brightness/contrast.

Downloading speed/time was also not an issue in the Stand-alone study, as the questionnaire was preloaded onto the computer. All respondents were able to open up the large images very quickly, and this option was not accompanied by a possible psychological reluctance to unduly extend the survey time.

To overcome a problem of the images being ‘too similar’ and the differences being ‘difficult to distinguish’\(^5\), a brief text description was included in each choice set, and text was used to highlight the differences in the images being presented. This resulted in the percentage of respondents claiming that the images were ‘too similar’ being reduced to just over 6% (compared with approximately 19% in the Internet study). Furthermore, the percentage of respondents claiming the images were of ‘poor quality’ and/or ‘too dark’ was now only 3% (compared to 15% previously).

Unlike the Internet study where the most common comments related to the images themselves, popular comments from the stand-alone study focus on the attributes displayed within the images. Approximately 12% of respondents said that trees influenced their choices\(^6\). This compares with only 1% of Internet respondents. 11% of respondents said that the coloured paving negatively influenced their choices (compared with only 1% of Internet respondents). Slightly less than 5% of respondents said paving stones influenced their choices but did not mention whether they were referring to the grey or coloured stones. 3% said that bollards influenced their choices.

6% of stand-alone respondents said the survey was confusing and were not entirely clear about what they were doing. It is possible that the confusion experienced by some respondents relates to the nature of choice experiments in general and not specifically to this study. In most choice experiments, respondents are presented with several choice sets with alternatives that differ slightly. It is well accepted that the as number of possible choice options increase, so to do the cognitive demands associated with making choices, and thus the level of confusion increases (Blamey et al. 1997).

Almost 5% of respondents said that cost influenced their choices. Other comments relating to the cost variable include:

- upgrades should be accounted for in planning budgets;
- total costs should be given; and,
- the money would be better spent solving Aberdeen’s traffic problems.

Nearly 5% of respondents would have appreciated more information concerning, for example, the materials used, maintenance and the aims of the changes. Nearly 5% would have liked to specify the options or select the features they liked best, and view all the images at once.

The differences in the types of comments made by the Internet and stand-alone respondents suggest that when larger, brighter images are provided (which are fast to download and open up), respondents are better able to concentrate on image content rather than on technical issues. This would suggest that using a standalone computer is more suitable for presenting detailed images to

\(^4\) Or that it was ‘nice and short’.

\(^5\) As suggested by the Internet respondents

\(^6\) No mention was made about the influence being a positive or negative one.
respondents\textsuperscript{7}, and some level of text to highlight differences in the images is required.

3.5 Image realism and easy of answering the questionnaire

In addition to the open-ended questions that allowed respondents to make comments about the questionnaire, several closed-ended questions were also asked. These included:

- How realistic do the images look?
- How easy or difficult was the survey to answer?

From Table 1, a quarter of the Internet respondents said that the images looked ‘very realistic’. This compared with nearly half (43\%) of the stand-alone respondents. The differences in these results could again be a result of monitor size and the ease of opening up larger images on the stand-alone computer, compared to the Internet. Less than 2\% of the stand-alone respondents thought that the images looked ‘very unrealistic’, compared with 5\% of the Internet respondents.

<table>
<thead>
<tr>
<th>Table 1: Do the images look realistic?</th>
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<tr>
<td>% Internet respondents</td>
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<tr>
<td>Very realistic</td>
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<tr>
<td>Fairly realistic</td>
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<tr>
<td>No opinion</td>
</tr>
<tr>
<td>Fairly unrealistic</td>
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<tr>
<td>Very unrealistic</td>
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<td>[100.0]</td>
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Table 2 provides a summary of how easy or difficult respondents found the survey. Almost 60\% of the stand-alone respondents, and 46\% of the Internet respondents found the survey ‘very easy’ to answer. None of the stand-alone respondents and only 3\% of the Internet respondents thought the survey was ‘very difficult’.

<table>
<thead>
<tr>
<th>Table 2: How easy or difficult did you find the survey to answer?</th>
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<tr>
<td>% Internet respondents</td>
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<tr>
<td>Very easy</td>
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<tr>
<td>Fairly easy</td>
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<tr>
<td>No opinion</td>
</tr>
<tr>
<td>Fairly difficult</td>
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<tr>
<td>Very difficult</td>
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<td>[100.0]</td>
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Overall, Tables 1 and 2 suggest that the majority of respondents thought the images were realistic (Internet: 81\%, Stand-alone: 88\%) and the questionnaire was easy to answer (Internet 77\%, Stand-alone: 88\%).

4: Discussion

This research was concerned with an appraisal of validity for the methodology. Although a limited number of environmental economic studies in the past have attempted to use images as part of the survey, this research was innovative in the use of images to convey almost all aspects of the choice scenario. In addition, by using fully computer generated environments, the researchers were able to realise far greater control over the contents of scenes, than if using photographs.

The main findings of this study can be categorised under two headings, namely, the effectiveness of the “visualisation” within choice experiments, and the technical limitations. With regard to the choice experiment, results from the survey (Davies & Laing 2001) indicated that respondents were able to understand contents of the images, and that a number of the modelled objects were found to have a significant influence on choice. With regard to technical limitations, the research used an Internet browser to collect data for reasons of widespread compatibility and inclusiveness. Due however to current limitations and variation between user equipment and connection speeds, some users suggested that they were distracted from the survey by technical barriers. The subsequent stand-alone study served to show, however, that most of these barriers can be overcome, and that the method appears to offer great potential for the future.

This research has raised a number of important issues which merit further development. The results suggest that the use of “virtual” environments holds potential for greater use within environmental economics. Future work should at least begin to explore the extent to which more immersive environments could be used, or ways in which more interactive models could be used to capture data. As the level of realism possible in virtual models increases, the possibilities for using models as either surrogate or entirely theoretical environments are clear. A balance must be found between realising the benefits of such models, and the richness inherent in using actual environments.

\textsuperscript{7} At least until standard Internet connections become faster.
5: References


Davies, A. & Laing, R.A. 2001, Designing choice experiments using focus groups: Results from an Aberdeen case study, research report, Robert Gordon University and Scottish Enterprise, Aberdeen


Louviere, J.J. 1994, Relating stated preference measures and models to choices in real markets, paper presented at the DOE/EPA Workshop on Contingent Valuation to measure non-market values, Herndon, VA, May.


Acknowledgements

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Figure 1 - sample images from the study