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Using images to measure qualitative attributes of public spaces through SP surveys

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Abstract

Stated preference choice experiments can benefit from the use of images to describe complex scenarios such as public spaces or urban infrastructure. However, images will be perceived subjectively by users who will probably understand them in a more qualitative than quantitative way. A method to quantify the relevance of qualitative attributes of public spaces such as beauty, safety or security is proposed. The method is based on the sequential estimation of discrete choice and latent variable models. Two case studies are described and the complexity of the construction of images is discussed. Results show that the proposed method allows the inclusion of qualitative features in choice models, but the use of images introduces a bias in the perception of the magnitude of design attributes that should be analysed carefully.

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1. Introduction

Design of urban infrastructure and public spaces is a topic of major relevance for cities as these are the main elements that connect places, people and activities, providing common areas for social interaction and facilitating integration of communities. Successful design should encourage intensive use of public infrastructure and space in a
way that is beneficial for society, thus justifying the investment of resources. For this, the design process must identify which attributes and characteristics are relevant for potential users, in order to generate attractive projects. This analysis (if performed) is usually done in a qualitative way, characterising the preferences of users through interviews or focus groups where specific cases studies are discussed and explored. However, this approach may not be enough when the relevant attributes are subjective or abstract, when the relative marginal value of attributes needs to be known or when a generalised and quantifiable understanding of individual preferences is required in order to economically evaluate hypothetical scenarios.

There is abundant evidence showing that qualitative attributes of urban space and infrastructure have an important effect on user behaviour (Handy et al., 2002; Ewing et al., 2003). For example, perceived safety, comfort and ease of access may encourage the use of public spaces (Khisty, 1994; Shriver, 1997), encourage the performance of particular activities like sports (Davison and Lawson, 2006; Heath et al., 2006) or influence the choice of transport mode, especially where exposure of the user to the environment is higher, as in walking or cycling (Antonakos, 1994; Zacharias, 2001; Hunt and Abraham, 2007).

While individuals usually perceive public spaces qualitatively, it is clear that qualitative attributes are a subjective interpretation of quantitative features of space. A typical example of this is perceived safety of public spaces, modelled through structural equations relating safety to physical features of space (Barker et al., 2003; Blöbaum and Hunecke, 2005). For a review of quantitative methods to analyse urban form and how it is perceived see Clifton et al. (2005).

Identifying which (and how) quantitative attributes contribute to each qualitative or subjective feature is not straightforward. For example, it has been noted that the presence of trees may increase the sense of safety in a public area (Kuo et al., 1998). While the presence of trees is an attractive feature by itself (Smardon, 1988), the positive effect on perceived safety is not obvious and, if not modelled explicitly, may be confounded. Moreover, other quantitative attributes may be contributing to the qualitative feature and should also be considered in the modelling effort. For example, Fanariotu and Skuras (2004) proved that omission of beauty indicators in landscape evaluation produces bias in the estimation of environmental welfare, even when all the variables used in the indicator are included. In general, there is a difference between the objective environmental quality of space (measured by quantitative attributes) and perception of users (Adamowicz et al., 1997), suggesting that (perceived) qualitative attributes should be explicitly modelled as a function of measurable attributes of both the object or space in question and the decision maker.

Measuring the preferences of users generally requires using stated preference surveys, especially when the subjects are designs, scenarios or projects that do not exist yet. In particular, stated preference choice experiments are good tools to evaluate, for example, environmental quality of physical spaces because they allow calculation of the relative value of attributes (Boxall et al., 1996; McFadden, 1974). The main difficulty with this kind of tool is representing the scenarios in a way that properly conveys the nature of all the features (both quantitative and qualitative) the space or object would have in reality. For example, use of text for the description of a scenario requires respondents to read, interpret and visualise (or imagine) the situation by themselves, which is clearly limited and a possible source of bias if the scenario is complex, such as a public space.

Images are representations that can be more accurate than text because they explicitly show the physical features of the scenario to the respondent. For example, Strazzera et al. (2010) studied the use of images in stated preference surveys in order to identify preferred design attributes for urban refurbishing processes. Sillano et al. (2006) and Iglesias et al. (2013) used images to measure the perception of safety in neighbourhoods as a function of urban design variables. Torres et al. (2013) used images to describe the level of maintenance of a street to measure its effect on location decisions. However, despite the clear advantages over text-only based description, images are still far from describing choice scenarios in a completely realistic way, since they lack volume, texture, temperature and sound. Moreover, when the scenario involves a public space, there are dynamic features that cannot be described with static pictures, such as the movement of objects or people. All these elements are hard to illustrate in traditional surveys, especially when the alternatives are complex scenarios like public spaces, where the description of alternatives can be ambiguous or incomplete and will be perceived in a subjective way by the respondent.

In discrete choice models, the subjective attributes that describe alternatives beyond quantitative attributes are usually considered part of the choice context (Oppewal and Timmermans, 1991) rather than intrinsic attributes of the
alternative. Modelling techniques traditionally aggregate the effect of contextual and subjective attributes of the alternatives in dummy variables that work as alternative-specific constants. This is usually not a problem if the alternatives can be properly labelled and categorised, but it may produce endogeneity problems if a particular subjective attribute is relevant and alternatives cannot be labelled appropriately (Guevara and Ben-Akiva, 2006; Guevara and Ben-Akiva, 2012). This means that, if the alternatives differ mainly in design details that will have an effect on subjective features, labelling will fail to capture the preference for these design attributes. The reason is because labelling represents an ex-ante aggregation or abstraction of the attributes in a qualitative feature that, although possibly meaningful for the decision maker, provides little information to any modelling effort attempting to measure how the decision maker builds the labels and relates them with attributes in their own cognitive process. Therefore, design details should be explicitly accounted for by the analyst and incorporated in the models. However, users will not explicitly observe these details but, instead, will perceive the space or object as a whole in subjective terms.

Subjective perception can be captured through psychometric indicators, as a measurable manifestation of the effect of unobserved characteristics in the preferences of individuals, usually treated as latent variables or latent classes (Walker and Ben-Akiva, 2002; Walker, 2006). For example, Yanez et al. (2010) modelled subjective perception of qualitative transport mode attributes like comfort, safety and ease of access and La Paix et al. (2013) used latent variables to show that neighbourhood characteristics have an influence on the user’s spatial perceptions that end up influencing travel behaviour. Hurtubia et al. (2014) used psychometric indicators to estimate latent class models where decision makers are categorised according to their subjective bias to particular transport modes. In general, in latent class or latent variable discrete choice models, the latent construct is associated with the decision maker, accounting for perception bias, attitudes or lifestyles; see Ben-Akiva et al. (2002) for further examples. In this article, a framework is proposed where the latent variable is, instead, a qualitative feature of the alternative that depends on the subjective perception of decision makers.

This research explores the combination of methods for visual representation of alternatives with the use of psychometric indicators for measurement of qualitative attributes. The paper is organised as follows. Section 2 briefly proposes a framework for measurement of the perception of qualitative attributes that is based on integrated latent class (or variable) and choice models. Section 3 discusses the difficulties of constructing images to describe alternatives that will be used in stated choice experiments. Sections 4 and 5 describe the generation of images and some preliminary results for two stated preference surveys measuring preferences in complex scenarios such as an urban street or a bike lane/path. Finally, Section 6 concludes the paper and identifies further work for this line of research.

2. Framework for measurement of qualitative attributes

A framework to model the perception of qualitative attributes of public spaces within discrete choice models is proposed. The method is based on the Generalized Random Utility Model (Walker and Ben-Akiva, 2002), but replaces the latent variables for qualitative features of the public space. The main difference is that, traditionally, latent variables account for unobserved characteristics of the decision maker and, in most cases, do not depend on attributes of the alternative (for counter-examples of this see Ben-Akiva et al., 2002 and Yanez et al., 2010). Figure 1 shows the proposed modelling framework, replacing the latent variable model for a more specific “Qualitative Feature Measurement Model”. In this model, additional properties of the alternative or scenario ($z_i$), that are considered to be not explicitly perceived by the decision maker (such as geometry, dimensions and other design variables), are related to perceived qualitative features (such as safety, comfort and beauty) through structural equations and measured through psychometric indicators. The choice model is a standard one, where attributes of the alternative ($x_i$) and characteristics of the decision maker ($x_n$) are explanatory variables of a utility function that is related to observed choices through a measurement equation.

This framework is proposed for choice problems where alternatives are public spaces, urban infrastructure or other complex scenarios that can benefit from being represented through an image. The indicator of the qualitative feature measurement model should also be a question about an image, ideally the same one describing the chosen (or unchosen) alternative. For example, a question about the perceived level of safety, comfort or aesthetic value of the image associated with the chosen alternative could be used as an indicator of those qualitative attributes.
3. Constructing images for stated preference experiments

Public spaces and urban infrastructure are very complex objects because they have many attributes that, although measurable, are not explicitly perceived by decision makers. For this reason the use of images seems suitable to describe alternative designs or scenarios taking place in urban spaces or landscapes (Shafer and Brush, 1977; Palmer, 2004). However, the use of images presents a series of difficulties that should be carefully considered when designing choice experiments for stated preference surveys.

One basic problem is the complexity itself of the represented object. The number of variables or attributes describing even a simple urban scenario can be very large and, therefore, the number of possible combinations of attribute levels can be huge. This makes the experimental design process particularly complex: relevant variables should be chosen carefully, leaving a large set of attributes fixed across alternatives. This represents an additional problem since the fixed attributes, a common background to all alternatives, may not be negligible in their interaction with the variable attributes. For example, different lighting conditions can make the same object more or less attractive. Therefore, picking a fixed setting of lighting may introduce a bias towards alternatives containing that object. The scale of object in the image can also have an effect on perception of attributes, if the background (or fixed) elements are large, some variable attributes may seem smaller than what was originally intended. See for example the Ponzo Effect shown in Figure 2, where all cuboids have the same size but are perceived as different due to a forced perspective illusion. Moreover, if the alternatives are labelled, the background can be different between each label, making these problems even more complex.

Another problem is that when using images, perception plays a role that may be confounded with preferences. Public spaces and urban infrastructure can be characterised by a large set of quantitative (measurable) attributes but they are perceived by users in a qualitative way. A simple example of this are the dimensions of the object, which are not known by the user, who just perceives them generally as part of the context, without necessarily rationalising them. For example, a pedestrian sidewalk can be perceived as wide or narrow by the user but usually only the analyst or designer knows the exact width of it. Also, two users with different backgrounds may evaluate the same width as narrow or wide, depending on their subjective perceptions.

A more technical problem, but equally relevant, is the realism of the type of image used. Photo-montage or a composite of real pictures allows for a more realistic representation but is limited in control of the image attributes. Computer generated images allow for more control, although they may appear as less realistic, especially if noisy elements that appear naturally in real images are removed or not included. There is certainly a trade-off between the
use of real or synthetic images for stated preference surveys that, to our knowledge, has not been explored yet in the literature.

![Figure 2. Example of Ponzo Effect.](image)

The most relevant issue is to provide proper context to the image, especially if the presented scenarios show spaces or objects that do not exist yet. In stated preference mode choice or travel surveys, context is usually achieved by making respondents think about their latest or usual trip and the presented alternatives are built based on their answer. This may be difficult to do when presenting images of public spaces since the alternatives are usually for a completely new or hypothetical scenario. It is possible to think of ways to provide context to the respondents, such as making them think of similar places they have visited, but this is also a topic that has not been explored in the existing literature.

In summary, generating images to describe alternatives for stated choice surveys is a complex task and the sources of noise and/or bias are not clearly identified yet. Taking that into account, and considering the previously mentioned issues, at least the following list of aspects should be taken into account when generating images to be used in stated preference choice experiments:

- position of focal point or vanishing point of the image
- distance between elements
- perspective (point of view) in terms of height, width, angle and person (assuming that the image is a first person view of the scenario)
- relevant planes or surfaces (such as walls) and their relative positions
- rhythm or frequency used to show a repeating element
- colour saturation
- proportions between included elements (scale)
- texture of surfaces.

The list excludes one of the main considerations when generating images to describe public spaces or infrastructure, which is the presence (or not) of particular elements and their physical characteristics. This is a problem that, although complex, can be treated using the existing literature and well known experimental design methods. This is shown in the following sections, where two stated preference surveys that used images to describe hypothetical design scenarios of public spaces are described.
4. Sidewalk design survey

The original objective of this survey was to evaluate the effect certain elements in a street have on perceived security (more details can be found in Hernandez, 2013). An unlabelled set of alternatives was constructed, always showing the same street from a first person perspective with the variable attributes selected based on preliminary interviews and literature relating urban attributes design to walkability and use of public spaces (Ewing and Handy, 2009; Carmona, 2010). The attributes and levels included:

- Transparency of the facades, where more windows imply visual control from the neighbours and should increase perceived safety. Four levels of transparency were defined in terms of percentage of the facade that is replaced by windows (0%, 15%, 60% and 80%). In order to make this realistic, not only the percentage of transparency was modified between levels, but also the scale and the type of land use.
- Presence of parked cars: two levels were defined, one where street parking is allowed and one where no parked cars are observed.
- Presence of trees: treated in absolutes (two levels: with or without) where trees appear in sequence on the sidewalk but the prominence of the first one is significant.
- Presence of people: two levels were defined, a level with few people (3 pedestrians) and a level with more people (7 pedestrians).
- Width of the sidewalk: two levels were defined, a “narrow” level (3 metres) and a “wide” level (5 metres).
- Colour of the facade: two levels were defined, a level where all colours of the facades are saturated (to 66%) and another level with low (33%) saturation, nearer to grey colours.

The combination of all possible levels for the six variable attributes produced a total of 128 possible combinations that were reduced, through an orthogonal experimental design, to 16 combinations or scenarios that were translated into images. Special care was taken when choosing feasible combinations of attribute-levels, in order to avoid the creation of alternatives that will be systematically dominant or dominated. This is particularly relevant in this type of choice experiment, where variables like price or time are not included and, therefore, the trade-off must take place only between the already described attributes. Figure 3 shows the images used in the survey.

The survey presented four choice situations with two alternatives to each respondent. Each alternative was described by its corresponding image only. After the last choice scenario, additional questions were asked on the perceived beauty, security and quality of life of each of the previously chosen alternatives. These additional questions, where respondents rated the perceived qualitative attribute from 1 to 10, were designed to be used as indicators for the qualitative feature measurement model described in Figure 1. Additionally, general statements on perception of beauty, security and urban quality were presented to the respondents, who were asked to rate their level of agreement using a five-level Likert scale (from total disagreement to total agreement). For example, statements such as “I avoid using my cell phone in the street because I fear it will be stolen” or “We should have more cops on the street” were used as psychometric indicators of the general concern for urban security.

The survey was executed online using the Qualtrics Research Suite (http://www.qualtrics.com/). A total of 250 valid and complete answers, adding to a total of 1,000 choices, were obtained. The sample was randomly generated using a “snowball” approach (Goodman, 1961). Of the respondents, 59% were male, 75% were between the ages of 18 and 30, 25% were between 31 and 40 and the remaining were over 41 years old. A large share of the sample (70%) reported having university level studies, indicating that this is clearly a biased sample although sufficiently heterogeneous for this proof of concept.

4.1. Results

As a first modelling attempt, a simple binomial logit, using a linear-in-parameters utility function specification, was estimated using BIOGEME (Bierlaire, 2003). The potential panel effect was ignored and alternative-specific constants were not estimated since the alternatives are unlabelled (preliminary estimations showed that alternative-specific constants for this model had small and non-significant values). Results are shown in Table 1. As expected,
wider sidewalks with trees, presence of people, transparent facades and no street parking are preferred by users. Only colour saturation of the building turned out to have a negative (although not significant) effect.

Figure 3. Images describing street design scenarios.
Table 1. Basic choice model results.

| Parameter         | Value | Std error | t-test |
|-------------------|-------|-----------|--------|
| 0.255             | 0.114 | 2.24      |
| 2.55              | 0.161 | 15.84     |
| 1.324             | 0.272 | 4.87      |
| 0.361             | 0.124 | 2.91      |
| 0.433             | 0.116 | 3.73      |
| -0.133            | 0.116 | -1.15     |
| Log-likelihood    | -463.919 |        |
| N_obs             | 1000  |           |

In order to test the approach proposed in Section 2, a latent variable accounting for perceived security was incorporated in the model. The following utility function was considered for the choice model:

\[ U_{in} = \sum_k \beta_k x_{ik} + \beta_{security}SEC_{in} \]  

(1)

where \( x_{ik} \) is the k-th attribute of alternative \( i \) and \( SEC_{in} \) is a latent variable representing the level of security perceived in alternative \( i \) by decision maker \( n \). The latent variable is described by the following structural equation:

\[ SEC_{in} = relevance_n \sum_k \gamma_k x_{ik} \]  

(2)

where \( relevance_n \) is the perceived relevance of urban security in general for decision maker \( n \) and \( \gamma \) is a set of parameters describing the contribution of each design variable to the average perception of security of a specific scenario \( i \). This composite latent variable (which in practice is the interaction of two variables) should ideally be estimated against indicators collected in the survey, assuming randomly distributed errors, in a simultaneous process, together with the estimation of the coefficient of the choice model. However, as a preliminary test, \( relevance_n \) was estimated independently as a linear regression of attributes of the decision maker against the level of agreement with the statement “I avoid using my cellphone in the street because I fear it will be stolen”. The vector of parameters \( \gamma \) was also estimated independently as a regression of the attributes of \( i \) against the perceived level of security for the same alternative. Estimation results are shown in Tables 2 and 3.

Table 2. Relevance of security.

| Parameter      | Value | Std error |
|----------------|-------|-----------|
| intercept      | 0.326 | 0.449     |
| \( \alpha_{is,female} \) | 2.099 | 0.076     |
| \( \beta_{log.age} \) | 0.349 | 0.138     |
| R^2            | 0.5829 |           |
| N_obs          | 250  |           |
Table 3. Contribution of design variables to perceived security.

| Parameter     | Value  | Std error |
|---------------|--------|-----------|
| intercept     | 2.166  | 0.123     |
| $Y_{width}$   | 0.618  | 0.098     |
| $Y_{trees}$   | 0.813  | 0.108     |
| $Y_{transparency}$ | 0.761 | 0.045     |
| $Y_{people}$  | 0.547  | 0.097     |
| $Y_{no_parking}$ | 0.069 | 0.099     |
| $Y_{width}$   | 0.406  | 0.099     |
| R²            | 0.314  |           |
| N_obs         | 250    |           |

Results from Table 2 can be interpreted as women and older people being more sensitive to (or concerned about) security in public spaces. From Table 3 it is possible to infer that the presence of trees and people, urban designs with broader sidewalks, and transparent and colourful facades are perceived as more secure on average. The fit of the estimation is not very good, although it is high enough considering the relatively small number of observations. Taking the results from Tables 2 and 3 it is possible to compute the latent variable $SEC_{nl}$ from equation (2) and replace it in equation (1), which allows the estimation of a new choice model including perceived security as an explanatory variable. Since colour saturation was not significant in the basic choice model, it was removed from the new specification. Results for this model are presented in Table 4.

The inclusion of perceived security, modelled as the average perception of security as a function of the alternatives’ attributes and the relevance given by each decision maker, generates a positive parameter. This is consistent with expectations since an environment that is perceived as safer (less crime) should be preferred in general. The relatively low t-tests for $\beta_{security}$ and $\beta_{width}$ are reasonable, considering the correlation that $SEC_{nl}$ introduces (because it is a function of variables that are also present in the choice model). Estimation results should be improved if the estimation is performed simultaneously for both the choice model and the latent variable model.

Table 4. Choice model with latent variable results.

| Parameter     | Value  | Std error | t-test |
|---------------|--------|-----------|--------|
| $\beta_{width}$ | 0.152  | 0.164     | 0.927* |
| $\beta_{trees}$  | 2.134  | 0.189     | 11.291 |
| $\beta_{transparency}$ | 1.285 | 0.325     | 3.954  |
| $\beta_{people}$  | 0.336  | 0.162     | 2.074  |
| $\beta_{no_parking}$ | 0.319 | 0.149     | 2.141  |
| $\beta_{security}$  | 0.135  | 0.113     | 1.195* |
| Log-likelihood   | -453.491 |          |        |
| N_obs            | 1000   |           |        |

5. Bike lane/path design survey

The objective of this survey (more details can be found in Saud, 2014) was to evaluate which aspects of urban space, in particular of cycling infrastructure, have a positive influence on the preferences of cyclists. For this, two sets of alternatives were constructed: one where the respondent faces a road and one where the respondent faces the sidewalk. In both cases a bicycle handlebar is shown to suggest that the scenario involves cycling. The first set can be labelled as “sidewalk” and the second set can be labelled as “road”. This distinction was introduced in order to
detect the preferences of cyclists for using the road or the sidewalk, which is currently a controversial topic in Santiago de Chile. In the choice experiment one alternative was always of the type “sidewalk” and the other “road”.

Besides this, several variable attributes were identified as relevant and considered in the experimental design before the generation of the images to use in the stated preference survey. These attributes were identified through preliminary interviews of urban cyclists and scientific literature on the topic (Antonakos, 1994; Hunt and Abraham, 2007; Kemperman and Timmermans, 2009; Forsyth and Krizek, 2011):

- presence of a bike lane painted on the ground (yes or no)
- presence of people on the sidewalk (few or many)
- presence of vegetation/trees (abundant or scarce)
- presence of buses on the road (yes or no)
- width of the road lane or sidewalk (wide or narrow)
- type of land use in the surrounding area (green area, mid scale commerce, large scale commerce).

A subset of relevant combinations was generated through an orthogonal experimental design, generating 16 images for the “sidewalk” label (see Figure 4) and 16 for the “road” label (see Figure 5).

The survey presented three choice experiments to each respondent, always including a “sidewalk” and a “road” type of alternative. As in the survey described in Section 4, qualitative features of chosen alternatives were measured through questions where the respondent rated the images in terms of perceived safety and satisfaction.

Since alternatives are labelled, and considering the potential issues already discussed in Section 3, it was deemed relevant to measure the perception of the magnitude of physical attributes by the respondent. For example, it was important to know if what was designed as “wide” would also be considered “wide” by the respondent and, if possible, to model this bias in perception as a function of socioeconomic attributes of the respondent. To do this, in one of the choice experiments, additional questions on the perception of three particular attributes (presence of trees, presence of people and width of road lane or sidewalk) were included.

The survey was executed online using a snowball sampling approach with the Qualtrics Research Suite (http://www.qualtrics.com/). A total of 354 surveys were completed, including 1,025 correctly answered choice experiments. Of respondents, 62% were female and 55% were between the ages of 18 to 30, while 33% were in the age range of 31 to 40. An interesting feature of the sample is that 46% of respondents declared using the bicycle for commuting four or more times a week, indicating a bias towards experienced urban cyclists.

5.1. Results

A binomial logit model was estimated using a specification with alternative specific parameters, and potential panel effects were ignored in this first modelling attempt. Results are shown in Table 5.

As expected, wider spaces with bike lanes are preferred by the users. The presence of buses and commercial land use has a negative effect for the road alternative while the presence of green areas has a positive effect for the sidewalk alternative. The alternative-specific constant for the “sidewalk” alternative is negative and relatively large, indicating a strong bias against riding on the sidewalk. This is probably explained by the large number of frequent bicycle commuters among the respondents, who are more likely to behave like “vehicular cyclists” and prefer to share the road with other vehicles (Pucher, 2001).

Although trees and people are obstacles and were expected to have a negative effect on the utility, they have positive parameters, but with a relatively low statistical significance. A possible cause of this may be a dissonance between what was defined as “wide” or “abundant” and how it was actually perceived by the respondent.
Figure 4. Images describing sidewalk cycling scenarios.
Figure 5. Images describing road cycling scenarios.
Table 5. Choice model results for bike lane survey.

| Parameter            | Value  | Std error | t-test |
|----------------------|--------|-----------|--------|
| Sidewalk             |        |           |        |
| ASC<sub>sidewalk</sub> | -1.26  | 0.238     | -5.29  |
| β<sub>lane</sub>    | 1.07   | 0.172     | 6.24   |
| β<sub>width</sub>   | 0.299  | 0.155     | 1.93   |
| β<sub>trees</sub>   | 0.137  | 0.16      | 0.86*  |
| β<sub>green_area</sub> | 0.493  | 0.177     | 2.78   |
| β<sub>people</sub>  | 0.166  | 0.15      | 1.11*  |
| Road                |        |           |        |
| β<sub>lane</sub>    | -0.307 | 0.156     | -1.98  |
| β<sub>width</sub>   | -0.841 | 0.159     | -5.29  |
| Log-likelihood      | -602.464 |         | |
| N<sub>obs</sub>     | 1025   |           | |

To explore if this dissonance actually exists, respondents were asked about perceived level of specific attributes (number of people, presence of trees and width of the road/sidewalk) in randomly selected alternatives (one from each of the sets shown in Figures 4 and 5). The question was presented in simple terms, asking if the attribute in the image was “high” or “low”, and answers were then compared with the actual level of the attribute in the design of the alternative. Table 6 shows the results for this where “under-estimate” indicates the percentage of answers where the attribute was perceived as “low” when it was actually high by design and “over-estimate” is the opposite case. There is a significant share of respondents who either under or over-estimate the magnitude of the presence of people, trees or the width of the road/sidewalk. This confirms that an unexpected distortion is taking place, probably due to the noise introduced in the additional (uncontrolled) attributes that define the fixed context of the label or type of alternative.

Table 6. Perception of magnitude of attributes.

| Variable | Under-estimate | Over-estimate |
|----------|----------------|---------------|
| People   | 25%            | 8%            |
| Trees    | 28%            | 7%            |
| Width    | 27%            | 21%           |

A possible way to account for this distortion is to model the perception of the magnitude of the attributes in a way that is similar to that proposed here for qualitative attributes. For example, the distance between perceived and actual magnitude could be used as an indicator of the perception bias and this bias could be modelled as a function of socioeconomic attributes. This indicator could be used to estimate latent classes in the way proposed by Hurtubia et al. (2014), allowing identification of (and control for) groups of users who tend to misestimate the magnitude. This will be the subject of further research.

6. Conclusion

A framework to measure the qualitative attributes of public spaces is proposed and tested in a survey to measure the preference for urban street design. Although not estimated simultaneously with the choice parameters, a latent variable measuring perceived security is included in the utility function specification with reasonable statistical
significance, despite the correlation between explanatory variables in both the choice model and the latent variable model. A second survey is described, finding that respondents tend to misestimate the magnitude of attributes included in the images. This represents a problem that could be addressed using a similar method to the one proposed to model qualitative attributes.

The main issue with the use of images for stated preference experiments is the lack of control for attributes that are not explicitly included in the design by the analyst. For example, the difference in overall temperature of colours between the scenarios shown in Figure 4 and Figure 5 is an unintended characteristic that emerges spontaneously from the inclusion of different elements during the photomontage process. The analyst could avoid these types of problems by choosing more neutral colours in the included elements, although this could have unknown effects on the respondent’s perception (see the discussion in Section 3 about the benefits and disadvantages of using realist images).

As a general conclusion, use of images for stated preference choice experiments presents advantages over more traditional representations such as text, but introduces new complexities that should be carefully analysed. This topic is not discussed enough in the literature.

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