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The Effect of Attribute Representation Methods on Noise Valuation: A Choice Experiment Study

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Abstract

Traffic noise has been known to severely affect human population. The valuation of traffic noise pose a significant challenge in choice experiments as respondents have little understanding of the physical measure of noise and its associated perception. As a result, several techniques have been developed that represent noise using different methods, either based on the level of noise exposure or the respondent's level of noise annoyance. This study examines the effect of different methods of attribute representation on respondents' attribute understanding and valuation. The study is focussed on residential choice and residential view and sunlight are important attributes that are examined along with traffic noise. The study demonstrates that the methods of attribute representation have an important effect on respondents' understanding of the attributes as well as in the subsequent valuation. It was found that attribute such as view is better represented using the location representation while noise is better represented using the linguistic method. Moreover, the method of attribute modelling also plays a significant role in the analysis as certain data input techniques are more suitable for some representation methods.

1 Introduction

Traffic related noise is an important externality significantly affecting human population. Though several techniques exist to value noise, choice experiment (CE) has been increasingly applied as it offers some advantages over contingent valuation (CV) and revealed preference techniques such as hedonic pricing (Arsenio *et al.*, 2000; OECD, 2007). However, an important problem associated with CE as well as CV in context of noise valuation lies in the adequate representation of the attribute. As the physical noise measure is generally more difficult for respondents to understand, following from Navrud (2002), two general types of noise representation can be observed in CE and CV studies – the exposure based and the annoyance based methods.

Studies applying the annoyance based method, which employ change in noise annoyance level as a representation method such as Bjorner, 2004; Fosgerau and Bjorner, 2006 and Li *et al.*, 2009, have shown that the presentation of the annoyance levels in the survey poses a significant challenge in its application. As the exposure based method allows the noise levels to be represented in several different ways, the examination of different noise representation techniques is easier under this method. Several methods of noise representation have been adopted within this technique, ranging from percentage or proportionate change (Saelensminde, 1999; Wardman and Bristow, 2004), auditory noise measure (Garrod *et al.*, 2002), residential location reference (Arsenio *et al.*, 2006) and proxy method (Carlsson *et al.*, 2004; Bristow and Wardman, 2006).

While some comparisons of different noise representation methods using priority ranking can be observed in Wardman and Bristow (2008), few examples can be found within the CV and CE literatures which examine the effect of different noise representation methods on attribute understanding and valuation. This paper addresses this issue using a residential CE survey by representing the attributes using the residential location reference as well as the linguistic representation method, to examine the effect of varying representation methods on respondents' understanding of the attributes. Thus, the effect of different attribute representation methods on attribute valuation will be examined in this paper.

The paper is structured as follows: Section 2 outlines the case-study area and the survey design, Section 3 provides the structure of the analytical models, Section 4 details the results and discussion while Section 5 gives the conclusions.

2 Background area and survey design

A noise residential survey was conducted in Telheiras area of Lisbon, Portugal to analyse the effect of different attribute representation methods on attribute valuation. The valuation CE was conducted during February-April 2008, with view, noise, sunlight and housing service charge as attributes in the SP exercise. Portugal has about 30% of the population exposed to more than 65 dB (A) of road traffic noise (Nijland and van Wee, 2005). The Telheiras residential area in Lisbon is surrounded by three main traffic roads (Avenue Norton de

Matos, Eixo Norte Sul and Avenue Padre Cruz). Based on the noise map of the city given by the city council of Lisbon (www.cm-lisboa.pt), some sections of the main traffic road surrounding the Telheiras area were observed to have noise levels greater than 70 dB (A). The daytime noise levels are given in the following map of the Telheiras area:

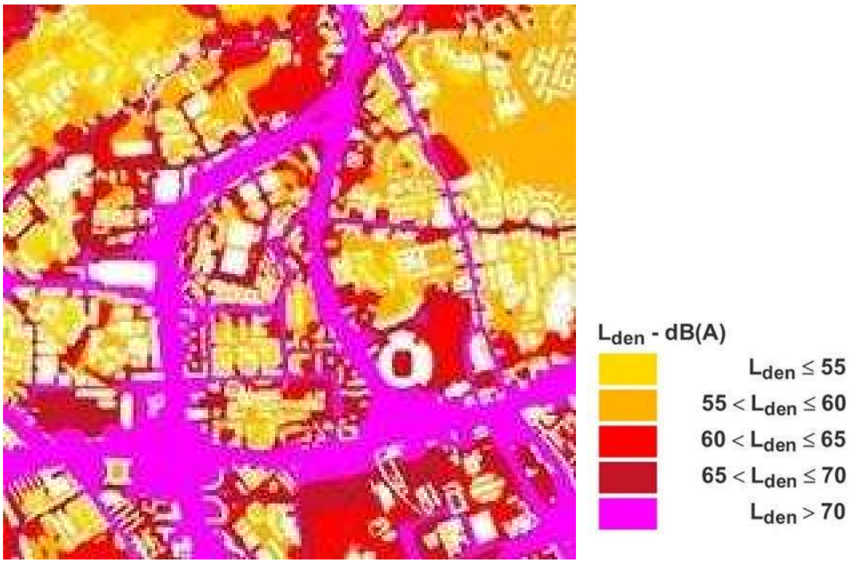

Figure 1 Lisbon Noise Map for Telheiras Area
(Source: http://www.cm-lisboa.pt/en/living-in/environment/noise/mapas-de-ruido)

The general questionnaire format and the survey site choice followed from a previous CE exercise conducted in the same area by Arsenio (2002). However, in comparison to the survey conducted by Arsenio (2002), which adapted a binary choice computer aided personal interview (CAPI) with the respondents' current apartment as the base alternative, the current study adapted an in-person paper based interview. As the focus of the current study was to examine the effects of different attribute representation methods on valuation, the pivotal design was not adapted.

The current survey was conducted in different phases and experiments based on the method of attribute representation and choice elicitation. The levels of the attributes view, noise and sunlight in the first phase of the survey were based on the relative locations of the apartments in the block (the location method) while for the second phase of the survey, the attribute levels were represented using linguistic categories (the linguistic method).

The questionnaires for both the phases of the survey comprised of questions on the perception ratings for the attribute levels for view, noise and sunlight, reasons for choosing the particular apartment and the residential location, number of hours spent in the apartment during weekdays and weekends, the presence and age of children in the household, the levels and causes of noise annoyance perceived in the apartment during day and night and socio-economic questions such as education, household income, occupation and gender. The choice experiment section of the questionnaire varied based on the phase and the experiment employed.

For both the phases of the survey which varied based on the attribute representation method employed, a fractional factorial orthogonal main effects design was developed based on the attribute level differences across the two alternatives. To eliminate the dominant choice problem in the second phase of the survey (which employed the linguistic representation method), variations were made in the sign of the housing charge difference for some of the scenarios, thus compromising on the orthogonality of the design. However, this was not expected to severly affect the modelling outcome. Simulation tests were carried out with different charge differences and coefficient values. The perception ratings for the attributes view, noise and sunlight were generated using random numbers over specific range. The simulation tests were conducted to test the goodness of model fit and the statistical significance of the coefficient values.

A total of 16 choice scenarios were offered to respondents across both the phases of the survey, with the number of attribute levels employed in the CE varying based on the method of attribute representation (Dave, 2011).

The following four apartment locations for the attributes view, noise and sunlight were chosen under the location representation method: apartment on the 6th floor on the facade facing the main traffic road (6 floor front), apartment on the 6th floor on the facade opposite the main traffic road (6 floor back), apartment on the 3rd floor on the facade facing the main traffic road (3 floor front) and apartment on the 3rd floor on the facade opposite the main traffic road (3 floor back). Four levels based on a difference design were employed for all the attributes in this phase of the survey.

For each of the apartment locations in the first phase of the survey, respondents were asked to provide a numeric rating as well as indicate a linguistic category for their perceptions of view, noise and sunlight in those apartments. While the numeric rating was sought on a scale from 0 (very bad) to 100 (very good), five linguistic categories: very bad, bad, neither, good and very good, were provided to obtain respondents' perceptions of the attributes. Thus, for each of the attributes except charge, a perception rating and a linguistic category were obtained for each of the four apartment locations.

Based on the numeric ratings obtained for each of the apartment types in the location survey, the mean numeric rating was computed. The following table provides the mean numeric rating with the location and the linguistic representation methods:

Table 1 Mean rating obtained for each attribute level with location and linguistic representation methods

Location Attribute	**Location Ratings**	**Linguistic Attribute**	**Linguistic Ratings**
View		**View**	
6 floor front	59.57	Good	64.29
6 floor back	59.68	Neither	44.93
3 floor front	46.60		
3 floor back	51.53		
Noise		**Noise**	
6 floor front	30.70	Noisy	25.96
6 floor back	50.58	Neither	42.47
3 floor front	29.39	Quiet	60.74
3 floor back	48.80		
Sunlight		**Sunlight**	
6 floor front	70.49	Very Good	86.17
6 floor back	66.24	Good	69.56
3 floor front	63.77	Neither	50.00
3 floor back	59.66		

The second phase of the survey which employed the linguistic representation method sequentially followed the first phase of the survey with the location representation.

The information on perception rating and linguistic categories from the first phase of the survey was used to form the levels of view, noise and sunlight under the linguistic representation method. The fuzzy logic technique using MATLAB was used to form the fuzzy membership functions for each of the linguistic categories. The fuzzy membership functions were used to inform the levels for the linguistic representation. This method was employed as the linguistic categories obtained from the first phase of the survey using the location method were too few in number (for example, most people considered sunlight for all the apartments in the block using the location method to be 'good'). As considering all the linguistic levels in the CE design would not be necessary, the information from the fuzzy membership functions along with the category counts from the location method and the average perception ratings was incorporated to form the attribute levels for the linguistic representation CE. Thus, for the second phase of the survey, linguistic categories 'good' and 'neither' were developed for the 'view' attribute, 'noisy', 'neither' and 'quiet' were developed for the 'noise' attribute and 'very good', 'good' and 'neither' were formed for 'sunlight'.

The respondents were again asked to provide a numeric rating from 0 (very bad) to 100 (very good) for each of these attributes across the different linguistic categories ranging from very bad, bad, neither, good and very good. Thus, for 'very good' view for example, the respondents were asked, 'if you were to give a rating from 0-100 for 'very good' view in this block what rating would you give?'. This information was collected in order to develop choice models based on the numeric ratings obtained from the respondents. Thus, the responses were modelled using both categorical and numeric data, for both the location and the linguistic representation methods. The questions eliciting respondents' numeric ratings preceded the choice experiment for both the phases of the survey.

Simulation tests for both the representation methods prior to the survey revealed that the experimental design developed was satisfactory.

Table 2 Attribute levels for linguistic representation survey

	Level 1	**Level 2**	**Level 3**
View	Good	Neither	
Noise	Noisy	Neither	Quiet
Sunlight	Very good	Good	Neither

The choice elicitation took the form of a split-sample survey with binary, one stage Likert and two stage Likert elicitation methods. The binary question asked the respondents to choose between alternatives A and B while the one stage Likert question asked the respondents to indicate their preference on a scale from Definitely A-Probably A-Uncertain-Probably B-Definitely B. The two stage Likert question asked the respondents to choose between the alternatives A and B and then indicate their level of preference certainty by stating whether they are 'very certain' of their choice or 'not so certain' (Dave, 2011). As this paper examines the effect of different attribute representation methods on choice, to simplify comparison of attribute representation methods, all choice data in this paper are converted to binary choice data.

The following figure provides an overview of the methodology employed in the survey design:

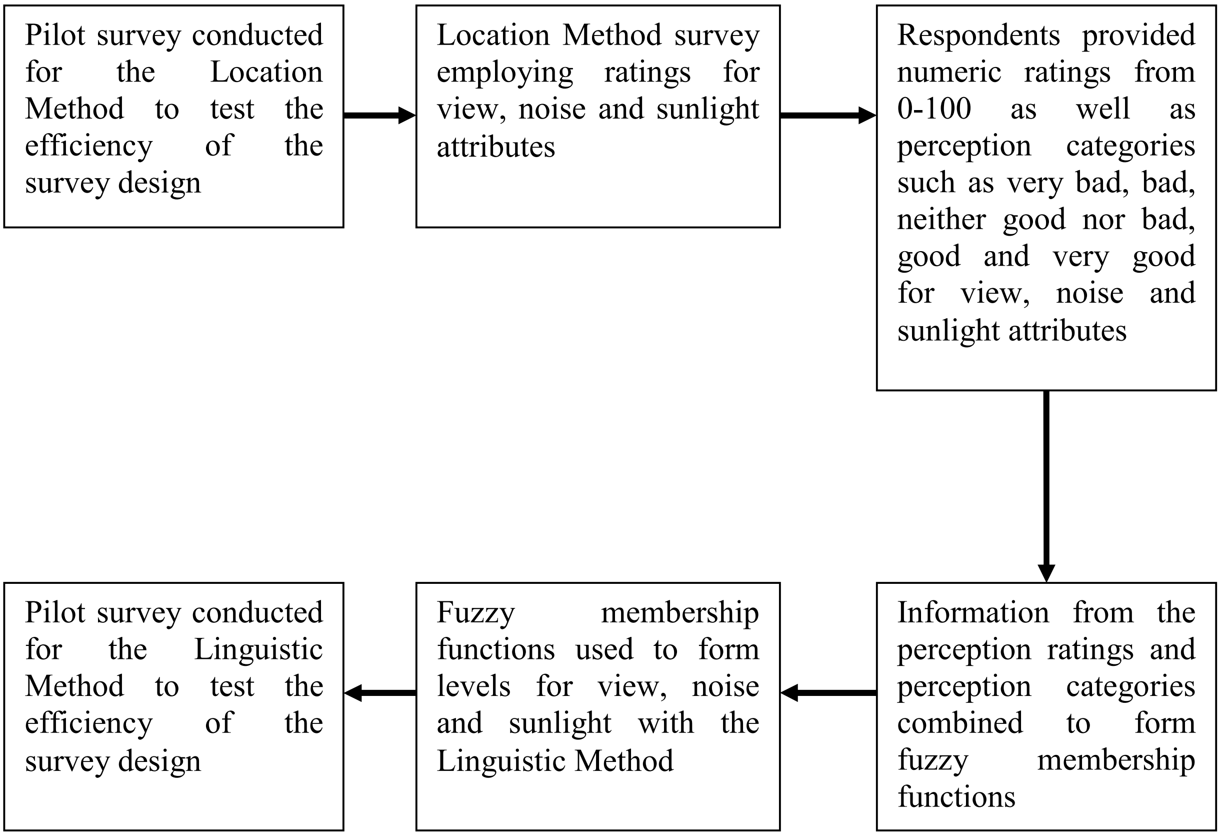

Figure 2 Survey methodology flow-chart

The main survey was conducted using paper based in-person residential interviews. Several apartment blocks in proximity to each of the three main traffic roads were identified and chosen for the survey. The interviews were conducted between 18:30 – 21:00 on weekdays and between 14:00 and 20:00 on weekends in order to obtain a fair representation of the employed section of the sample. A total of 222 respondents participated in the first phase of the survey while a total of 204 respondents participated in the second phase of the survey. The following are some of the socio-economic characteristics of the respondents across the location and the linguistic representation survey.

Table 3 Socio-economic characteristics across the location and linguistic survey

Characteristics	Location method (respondents = 222)	Linguistic method (respondents = 204)
Gender		
Male	43.7%	39.7%
Female	56.3%	60.3%
Age		
18-25	18.5%	24%
26-40	28.4%	24%
41-55	29.3%	31.4%
56-75	22.9%	18.1%
>75	0.9%	2.4%
Household Income (Euro/Month)		
< 1000	7.2%	5.9%
1000 – 2000	16.7%	16.2%
2000 – 3000	18.9%	22%
3000 – 4000	15.8%	9.8%
4000 – 5000	12.6%	6.9%
> 5000	7.6%	9.8%
No answer	21.2%	29.4%
Education		
Primary	2.7%	0.5%
Secondary	19.4%	19.6%
Graduate	60.4%	62.7%
Post-graduate	17.6%	17.1%
Occupation		
Part-time	14.4%	5.9%
Full-time	58.5%	58.3%
Unemployed	3.1%	3.4%
Retired	11.7%	13.2%
House based	1.3%	3.9%

Student	10.4%	15.2%
No answer	0.4%	0%
Day-time Noise		
Very Noisy	11.7%	13.2%
Noisy	34.7%	25.5%
Neither	36.5%	40.2%
Quiet	13.5%	19.1%
Very Quiet	3.6%	1.9%
Night-time Noise		
Very Noisy	6.7%	7.3%
Noisy	27.5%	21.6%
Neither	33.8%	23%
Quiet	27.9%	40.2%
Very Quiet	4%	7.8%

3 Analytical Models

For each of the attribute representation methods, the ‘view’, ‘noise’ and ‘sunlight’ attribute levels were incorporated in the model based on the numeric perception ratings obtained from the respondents for these attributes, as well as their dummy categorical values, for each of the alternatives. Thus, two different models were developed based on the data input method, for each of the representation methods. This was conducted in order to examine the most suitable data input method based on the attribute representation method used. While the number of dummy levels for ‘view’, ‘noise’ and ‘sunlight’ were fixed to four for the location representation method, based on the number of apartment locations used in the survey, the number of dummy levels for these attributes under the linguistic representation varied based on the linguistic categories developed for the survey. Thus, while ‘view’ had two levels with the linguistic representation, ‘noise’ and ‘sunlight’ had three levels each.

The pooled model comprised of a binary logit model which incorporated data from the binary response as well as the one and two stage Likert responses. The Likert scale responses were modified to a binary response. Thus, in case of the one stage Likert response which comprised of a five point scale, ‘Definitely A’ and ‘Probably A’ were coded as ‘Choice A’ while ‘Definitely B’ and ‘Probably B’ were coded as ‘Choice B’; the ‘Uncertain’ response was excluded from the analysis. This resulted in the exclusion of about 74 responses which were coded as ‘Uncertain’ for the location representation and 37 responses for the linguistic representation method. The following table provides a summary of the responses from each of the modified categories under the two Likert scale methods:

Table 4 Recoded choices from one and two stage Likert experiments

	Location Method		**Linguistic Method**	
	One Stage Likert	**Two Stage Likert**	**One Stage Likert**	**Two Stage Likert**
Choice A	497	551	460	504
Uncertain	74	-	37	-
Choice B	309	345	319	312

A linear additive utility function was developed for each of the alternatives, with the alternative specific constant (ASC) added to *(n-1)* alternatives. The ASC captures the average effect of unobserved factors not incorporated in the utility function (Train, 2003; Koppelman and Bhat, 2006). The models accounted for repeated observations by allowing for panel effects to be captured through the error components specification in BIOGEME 2.0 (Bierlaire, 2003; Bierlaire, 2008; Yanez *et al.*, 2010) with Modified Latin Hypercube Sampling (MLHS) procedure, as developed by Hess *et al.* (2006), to generate 500 draws.

The MLHS draws are formed by unidimensional sequences of evenly spaced draws, which are randomly shuffled to form a multidimensional sequence. These sequences result in a uniform coverage of the draws compared to the Halton sequence (Hess *et al*., 2006).

For binary choice ratings model, the general utility model can be expressed as follows:

$$U_A = \alpha V_A + \beta N_A + \gamma S_A + \mu C_A + ASC_A + \tau_A \quad (1)$$
$$U_B = \alpha V_B + \beta N_B + \gamma S_B + \mu C_B$$

Where,

V is the view attribute ratings

N is the noise attribute ratings

S is the sunlight attribute ratings

C is the housing service charge

ASC_A is the alternative specific constant for alternative A

τ_A is the error component added to account for panel effects in alternative A

In case of the linguistic dummy specification, the utility model took the following form:

$$U_A = \alpha_1 V_{A_1} + \beta_1 N_{A_1} + \beta_2 N_{A_2} + \gamma_1 S_{A_1} + \gamma_2 S_{A_2} + \mu C_A + ASC_A + \tau_A \quad (2)$$

$$U_B = \alpha_1 V_{B_1} + \beta_1 N_{B_1} + \beta_2 N_{B_2} + \gamma_1 S_{B_1} + \gamma_2 S_{B_2} + \mu C_B$$

Where,

V_{ij_n} represent view for (n-1) attribute levels

N_{ij_n} represent noise for (n-1) attribute levels

S_{ij_n} represent sunlight for (n-1) attribute levels

C_{ij} is the housing service charge for each of the alternatives

ASC_A is the alternative specific constant for alternative A

τ_A is the error component

4 Results and Discussion

Result from the binary logit model, given in Table 5, reveal that in case of the location representation method, the ratings data input method provides a better model fit in terms of the final log-likelihood and the adjusted ρ^2 values compared to the dummy input method. In case of the linguistic representation method, the dummy input method provides a better model fit based on these criteria than the ratings model.

Examining the coefficient estimates obtained from the models, it can be observed that the method of data input is quite significant in obtaining a meaningful and significant coefficient estimate.

Across the location and linguistic ratings specification, the attribute parameter estimates and their associated t-statistics (in parenthesis) reveal that the 'noise' coefficient has a higher value and statistical significance under the linguistic representation method while the 'view' coefficient has a more precise estimate with the location method. The statistical significance of each parameter estimate reveal the level of precision associated with the coefficient's estimation and can thus reflect the level of understanding associated with that attribute under each of the representation methods. In case of the 'sunlight' attribute, a higher parameter estimate is obtained with the location representation method, with the statistical significance only slightly lower than compared to the linguistic representation method.

Table 5 Binary logit (BL) model

Location attributes	Location ratings (t-statistics)	Location dummy (t-statistics)	Linguistic attributes	Linguistic ratings (t-statistics)	Linguistic dummy (t-statistics)
ASC			**ASC**		
Alt.A	0.491*** (6.84)	0.824*** (4.96)	Alt.A	0.276*** (4.59)	0.128 (1.30)
View	.0199*** (8.27)		**View**	.0186*** (5.03)	
6 floor front		0.336** (2.58)	Good		0.598*** (6.53)
6 floor back		0.434*** (3.45)	Neither		
3 floor front		-0.187 (-1.53)			
3 floor back					
Noise	.0259*** (11.92)		**Noise**	.0396*** (18.89)	
6 floor front		-1.15*** (-9.47)	Noisy		-2.02*** (-19.1)
6 floor back		-0.71*** (-3.30)	Neither		-0.65*** (-5.30)
3 floor front		-1.41*** (-6.44)	Quiet		
3 floor back					
Sunlight	.0248*** (8.09)		**Sunlight**	.0167*** (8.49)	
6 floor front		-.030 (-0.25)	Very good		0.849*** (8.44)
6 floor back		.541*** (3.26)	Good		0.601*** (3.70)
3 floor front		-.179* (-1.66)	Neither		
3 floor back					
Charge	-.0299*** (-21.31)	-.0305***(-21.44)	**Charge**	-.0209*** (-13.38)	-.027*** (-14.51)
ρ^2 w.r.t. 0	0.245	0.225	**ρ^2 w.r.t. 0**	0.155	0.193
adjusted ρ^2	0.243	0.220	**adj. ρ^2**	0.152	0.189
FLL	-1819.247	-1867.503	**FLL**	-1890.148	-1806.114
no. of obs.	3478	3478	**no. of obs.**	3227	3227
no. of indiv.	222	222	**no. of indiv.**	204	204

Coefficient estimate significant at *10%, **5%, ***1%, FLL – final log-likelihood

As the ratings model incorporated the numeric ratings for 'noise' from 0 (very noisy) to 100 (very quiet), a positive sign of the attribute coefficient is obtained in this case, in line with the theoretical expectations. The 'view' and 'sunlight' attributes were also rated from 0 (very bad) to 100 (very good). In case of the dummy specification, the parameter estimate obtained for each of the dummy levels is independent of the numeric ratings and is associated with each of the linguistic dummy levels.

The higher parameter estimate for 'noise' under the location and linguistic ratings specification compared to 'view' and 'sunlight' indicates that this attribute is valued relatively higher. Under the location dummy specification, it is observed that respondents perceive 'view' in apartments '6 floor front' and '6 floor back' to be better than '3 floor back', implying height is a significant factor affecting perception of good view. In relation to the apartment '3 floor back', a significantly high negative value for 'noise' for the apartment locations '6 floor front' and '3 floor front' imply that as per theoretical expectation this attribute is perceived to be worst on the facade facing the main traffic road. However, significant negative value for apartment '6 floor back' in relation to '3 floor back' also implies that in case of this attribute, the relative effect of height on the attribute perception varies based on which facade the apartment is located in. Coefficient estimates obtained for 'sunlight' under this model specification imply that the facade as well as the height has an important effect on the perception of this attribute, with the apartment on the sixth floor and on the facade opposite the main traffic road, having the most desirable sunlight level.

The linguistic dummy model provides expected signs and plausible coefficient values across the different attribute levels. It is observed that the noise levels are very significantly valued in relation to the base level ('quiet'). This implies that the respondents strongly consider the noise levels to be a disutility and give a high significance to 'quiet'. Respondents also value the view and sunlight attributes highly. A high statistical significance of all the coefficient estimates under the linguistic dummy model specification implies that the linguistic levels of the attributes are well comprehended by the respondents.

Comparing the attribute values and the t-statistics across the various models, it can be concluded that the 'view' attribute is more clearly understood under the location representation method while the linguistic representation method provides a clearer understanding of the 'noise' attribute. Moreover, for the location representation method, the ratings model provides a better indicator of respondents' choice while for the linguistic representation, respondents' choices are better explained by the dummy linguistic model.

Comparing the location dummy model with the mean numeric ratings provided for each of the apartments, it can be seen that in case of view, the coefficient estimates for sixth floor front and sixth floor back apartments are as per the expectations from the ratings obtained for these apartments. In case of noise, as per the mean numeric ratings provided in Table 1, respondents regard the noise level on the facade facing the main traffic road to be similar for the apartments on the sixth floor as well as on the third floor. The coefficient estimates from the binary logit location dummy model reveal that noise in the apartment third floor front is considered to have a higher disutility than noise in the apartment sixth floor front though both have a high and significant coefficient estimate. With the sunlight attribute, the coefficient estimates obtained for each of the apartments is different compared to the mean numeric ratings obtained for this attribute.

It can thus be concluded that for each of the attribute representation, a different data input method is more suitable. Moreover, when the right data input method is chosen for the attribute representation method, a more precise estimate of respondents' choices is obtained.

Table 6 WTP from BL model

Location attributes	**Location ratings Euro/month (t-statistics)**	**Location dummy Euro/month (t-statistics)**	**Linguistic attributes**	**Linguistic ratings Euro/month (t-statistics)**	**Linguistic dummy Euro/month (t-statistics)**
View	.665*** (7.99)		**View**	.889*** (5.42)	
6 floor front		11.01** (2.58)	Good		22.14*** (7.34)
6 floor back		14.23*** (3.46)	Neither		
3 floor front		-6.13 (-1.52)			
3 floor back					
Noise	.866***(9.69)		**Noise**	1.89*** (16.27)	
6 floor front		-37.7*** (-9.28)	Noisy		-74.8*** (-14.6)
6 floor back		-23.3*** (-3.30)	Neither		-23.9*** (-6.05)
3 floor front		-46.2*** (-6.35)	Quiet		
3 floor back					
Sunlight	.829*** (7.82)		**Sunlight**	.799*** (7.83)	
6 floor front		-.99 (-0.25)	Very good		31.44*** (7.70)
6 floor back		17.74** (3.28)	Good		22.26*** (3.59)
3 floor front		-5.87* (-1.66)	Neither		
3 floor back					

Coefficient estimate significant at * 10%, ** 5%, *** 1%

For the different attribute representation and data input methods, the willingness to pay was calculated for the attributes view, noise and sunlight. The delta method (Langford, 1994) was used to estimate the t-statistics around the WTP estimate. It was found that the 'noise' attribute is significantly valued across all the models. The negative sign of the WTP estimate for noise under the location dummy model is in line with theoretical expectations as the noise levels in each of the apartment locations is considered a disutility in comparison to the apartment on the third floor on the facade opposite the main traffic road. Examining the signs of the WTP estimate, it can be concluded that noise is considered a disutility for all attribute levels across the location and linguistic dummy models. As the WTP estimate for the noise attribute is based on a unit improvement in the noise level for the ratings model, the WTP estimate in this case, signify a utility for a unit improvement. In comparison to the base alternative in case of the location method, the view and sunlight attributes are considered worse (disutility) for the apartment on the third floor and facing the main traffic road.

In case of the linguistic representation method, it can be observed that under the ratings model, positive sign of the WTP estimate is obtained as it is considered as a utility (unit improvement) for each of the attributes. In case of the linguistic dummy model, a negative sign of the WTP estimate for the levels 'noisy' and 'neither noisy nor quiet' indicate that the respondents consider these attribute levels as a 'disutility'. In case of view and sunlight attributes, the attribute levels ('very good' and 'good') under this case are considered a utility.

With the linguistic dummy model, it was found that the respondents are willing to pay about Euro 74.8 per month to reduce the noise levels from 'noisy' to 'quiet' and Euro 23.9 per month to reduce the noise level from 'neither noisy nor quiet' to 'quiet'. In case of the 'view' attribute, respondents are willing to pay Euro 22.14 per household per month, for 'good' view, Euro 31.44 per household per month, for 'very good' sunlight and Euro 22.26 per household per month, for 'good' sunlight in relation to the 'neither good nor bad' levels of the respective attributes.

In case of the location ratings model, the respondents are willing to pay Euro 0.866 per month for one unit improvement in rating (or one unit reduction in noise) for the 'noise' attribute. A unit improvement in the respondents' rating is considered as a unit reduction in the rating of the noise perception. In case of the 'view' and 'sunlight' attributes, the WTP was found to be

Euro 0.665 per month and Euro 0.829 per month for a unit improvement in the ratings of these attributes.

Based on the coefficient estimates obtained from the location ratings model as well as the mean numeric rating for each of the apartment types in the location survey, the following WTP can be obtained in relation to the base apartment, 3 floor back:

Table 7 WTP from mean location rating for each apartment type

Apartment	View Euro/month (t-statistics)	Noise Euro/month (t-statistics)	Sunlight Euro/month (t-statistics)
6 floor front	5.35*** (7.99)	-15.68*** (-9.69)	8.98*** (7.82)
6 floor back	5.42*** (7.99)	1.54*** (9.69)	5.46*** (7.82)
3 floor front	-3.28*** (-7.99)	-16.81*** (-9.69)	3.41*** (7.82)
3 floor back	Base	Base	Base

Coefficient estimate significant at *10%, **5%, ***1%

The WTP values show that the apartment 6 floor front has the highest utility for sunlight but a disutility for noise. In case of the apartment 3 floor front, the attributes view and noise have a disutility while sunlight is moderately desirable. The apartment 6 floor back is found to have good levels of utility for view and sunlight and no disutility for noise. Thus, this apartment is found to be most desirable across all the main attributes (not considering the housing service charge).

The benefit estimates for the cost benefit analyses (CBA) can be computed in case of the location ratings method from a unit improvement in the numeric ratings of each of the attributes. This can then be related to the WTP for each of the apartment locations. In case of the linguistic representation, benefit estimates can be formed for improvement in the perceived ratings as well as the perceived noise levels. The noise levels can be linked to the annoyance scale to estimate the values for reduction in noise annoyance level. Moreover, where noise annoyance levels are used as attributes in the CE, the annoyance level scale can be associated with the physical noise levels and noise perceptions in the CE survey, to get the linkage between physical noise perception and noise annoyance levels.

Where noise reducing measures are used, results from the CE and the WTP estimates can be used to estimate the benefits from noise reducing measures in a CBA.

Comparing the location and linguistic methods for attribute representation, it can be seen that the location ratings model is more suitable for attributes such as view and sunlight while the linguistic dummy method is more suitable for the noise attribute. This implies that it is easier for the respondents to understand the levels of view and sunlight in terms of the location ratings of the apartments while in case of the noise attribute, the linguistic representation provides a better parameter estimate. Thus, the objective level of the view attribute, based on the location of the apartment provides a good representation of these attribute levels. The sunlight attribute was found to be well-represented with the location and the linguistic representation methods, though the location ratings model is slightly preferred over the linguistic model as it provides a higher parameter estimate with almost equivalent t-statistics. In case of the noise attribute however, the linguistic representation provides a better understanding of the attribute level compared to the location reference.

The difference in the coefficient estimates and their significance for the various attributes based on the method of attribute representation thus implies that the respondents comprehend and value the attributes differently based on the method of attribute representation used.

Attribute framing has been found to affect choices and cause preference reversals. Various studies reveal that the method of presentation affects choice (Tversky and Kahnemann, 2000; Kragt and Bennett, 2012; Windle and Rolfe, 2014). This paper has attempted to compare the effects of different attribute representation methods on respondents' understanding.

While several studies have been conducted that evaluate the impact from traffic noise using choice experiments (Garrod *et al*., 2002; Wardman and Bristow, 2004; Arsenio *et al*., 2006), few studies can be found that examines the effect of varying noise representation methods on respondents' understanding and valuation. This study has compared the effects of different attribute representation methods in the context of household choice. The results reveal that the method of attribute representation does affect choice and the valuation of attributes.

5 Conclusions

This paper has compared the methods of attribute representation and examined their effect on valuation. Attributes such as view, sunlight and noise were represented using apartment location method as well as the linguistic method. It was found that in case of the attribute such as view, the location method provides a clearer understanding of the attribute to the respondents as well as better valuation estimates. In case of noise, a higher and more precise estimate is obtained in case of the linguistic representation method. Sunlight is equally well represented using the location and the linguistic representation methods.

Noise was found to be valued at Euro 0.87 per household per month for a unit improvement in the ratings, with the location method while the value to reduce noise from 'noisy' to 'quiet' levels was found to be Euro 74.8 per household per month. View and sunlight were valued at Euro 0.67 per household per month and Euro 0.83 per household per month respectively. With the linguistic method, respondents were willing to pay Euro 22.14 per month to improve the view from 'neither good nor bad' to 'good' and Euro 31.44 per month to improve the level of sunlight in the apartment from 'neither' to 'very good'.

It was also found that different methods of data input were appropriate based on the representation method used. In case of the location representation, incorporating the data as respondents' numeric ratings is more appropriate than using categorical data, while in the case of the linguistic method, using categorical data such as the linguistic levels provides more precise estimates. Thus, in the case of choice experiments, a mixed method of attribute representation should be used, based on the suitability of the representation method. Extensive pilot study can help in the choice of a suitable attribute representation method.

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7 Declaration of Interest

No potential or actual conflict of interest.

8 References

Lisbon city council : www.cm-lisboa.pt

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