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Non-attendance and dual processing of common-metric attributes in choice analysis: A latent class specification

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ABSTRACT: There is a growing literature that promotes the presence of process heterogeneity in the way that individuals evaluate packages of attributes in real or hypothetical markets and make choices. A centerpiece of current research is the identification of rules that individuals invoke when processing information in stated choice experiments. These rules may be heuristics used in everyday choice making as well as manifestations of ways of coping with the amount of information shown in choice experiment scenarios. In this paper, using the latent class framework, we define classes based on rules that recognise the non-attendance of one or more attributes, as well as on the addition and the parameter transfer of common-metric attributes. These processing strategies are postulated to be used in real markets as a form of cognitive rationalization. We use a stated choice data set, where car driving individuals choose between tolled and non-tolled routes, to translate this new evidence into a willingness to pay (WTP) for travel time savings, and contrast it with the results from a model specification in which all attributes are assumed to be attended to and are not added up with parameter preservation. We find that the WTP is significantly higher, on average, than the estimate obtained from the commonly used full relevance and attribute preservation specification.

KEY WORDS: *Attribute non-attendance, common-metric attributes aggregation, parameter transfer, latent class, stated choice, willingness to pay.*

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1. Introduction

In recent years the major developments in choice analysis have been attributed to richer and more flexible generalizations of the basic multinomial logit model. A large number of papers have finessed the analytical structures of random parameters to uncover sources of systematic variation, introduced error components, and improved on estimation outputs through incorporation of subjective priors such as the alternative chosen. These advances have improved our knowledge of the role that observed and unobserved heterogeneity play in preference revelation (after allowing for scale); however they have also raised more fundamental questions about the underlying behavioural processes that individuals bring to bear on the information they are confronted with in reporting choices, especially in, but not exclusively, stated choice experiments.

A series of papers by Hensher (2006, 2008), Greene and Hensher (2008), Layton and Hensher (2008), Hensher (2008a), Hensher and Layton (2008), Hess and Hensher (2008), Puckett and Hensher (2008), Swait (2001), Cantillo et al. (2006), Scarpa et al. (2008) and Cantillo and Ortúzar (2005) are examples of a growing recent interest in the way that individuals evaluate a package of attributes associated with alternatives in real or hypothetical markets, and make choices. The accumulating empirical evidence suggests that individuals use a number of strategies derived from heuristics to represent the way that information embedded within attributes defining alternatives is used to process the context and arrive at a choice outcome. These include cancellation or attribute exclusion and attribute aggregation and parameter transfer where the attributes are in common units. (See Bonini et al 2004, Houston and Sherman 1995, and Gilovich et al. 2002 for a series of papers that synthesise the broader evidence under the theme of heuristics and biases).

Two methods are emerging to investigate the role of process heuristics – one involving supplementary questions on how attributes are processed, such as whether specific attributes are ignored or aggregated, and the other involving a specification of an anlytical model that can reveal the extent to which a particular processing strategy is being utilised across a sample. Although we are not able to suggest which method is closer to the 'truth' in capturing process strategy, we are engaged in continuing research to understand the behavioural implications of each method, and in time to establish a mapping between the two methods.

We explore a line of inquiry in which we jointly consider three broad classes of processing strategies or heuristics. The first is attribute non-attendance, where a specific attribute and its associated level are ignored by a respondent when evaluating alternative attribute packages (see Hensher et al. 2005, Scarpa et al. 2008, Hensher 2008a). The second heuristic relates to the way that common-metric attributes (e.g., partitions of travel time or cost) are jointly evaluated as either separate or combined attributes (see Layton and Hensher 2008); and the third heuristic is a variant of the second within a common-metric context in which the parameters associated with two partitioned attributes (e.g. free flow time and slowed down time) are transferred from one attribute to the other on the basis of some view on the role of each attribute (see Hensher and Layton 2008). Specifically, the parameter-transfer heuristic assumes that if a common-metric attribute (i.e., time or cost components) is greater in magnitude to the other attribute, then individuals transfer the parameter assigned initially to the former attribute to the latter attribute. We call this process 'attribute marginal disutility referencing'. This latter phenomenon has some plausibility. Anecdotally we find that some individuals tend to label the appeal of an alternative, where an attribute is a disaggregation of a candidate aggregation, in terms of the marginal disutility of the component that is the greatest in magnitude. Intuitively many car commuters (drawing on the empirical context herein) often highlight the least attractive perceived element of a trip which then becomes the preference identifier along that common unit dimension (e.g., 'I will not use that route because it has the worst congestion!).

Bertini and Wathieu (2006) and Thomas and Morwitz (in press) are recent contributions to a literature on attribute partitioning and numerical cognition that recognizes the role of the

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structural content of an attribute (in their case it is price) in preference revelation. Price partitioning is shown to act as an incentive to process multiple product dimensions. Although the interest in partitioning is common to our inquiry, our focus is different. We explore ways in which partitioned attributes, such as components of trip travel time (namely free flow time and slowed down or congestion created time), are used to reference particular cognitive experiences which results in the redefinition of the marginal (dis)utility of all attributes that have a common metric.

In this paper we implement the model specification method in the context of a stated choice data set where car driving individuals choose between tolled and non-tolled routes. A latent class model is specified in which specific restrictions are imposed on the utility expressions for each class to represent hypotheses on group adoption of pre-defined processing strategies. This is the first application, to our knowledge, that considers the role in choice experiments of a number of candidate attribute processing strategies in the context of a latent class model, without having to rely on stated processing responses from supplementary questions[1]. We translate the evidence into a willingness to pay (WTP) for travel time savings and contrast it with the results from the popular multinomial logit and mixed logit models in which full preservation of all attributes is traditionally assumed. We find that the WTP is higher, on average, than the commonly used specification.

The paper is organized as follows. Section 2 presents the latent class model. Section 3 describes the empirical context in which the hypotheses are tested, followed by Section 4 in which the evidence is presented including willingness to pay measures to value travel time savings, and contrasts this with the evidence obtained under the traditional full attribute preservation model. The paper concludes with a summary of the main findings.

2.   A latent class processing model of attribute non-attendance and common-metric addition and parameter transfer

The underlying theory of the latent class model posits that individual behaviour depends on observable attributes and on latent heterogeneity that varies with factors that are unobserved by the analyst. This heterogeneity can be represented by a model of discrete parameter variation. It is assumed that individuals are implicitly sorted into a set of Q classes, but which class contains any particular individual, is unknown to the analyst. The behavioural model is a logit model for discrete choice among J_i alternatives (known as a choice set), by individual i observed in T_i choice situations, given in (1).

$$\text{Prob[choice } j \text{ by individual } i \text{ in choice situation } t \mid \text{class } q] = \frac{\exp(\mathbf{x}'_{it,j}\boldsymbol{\beta}_q)}{\sum_{j=1}^{J_i}\exp(\mathbf{x}'_{it,j}\boldsymbol{\beta}_q)} \tag{1}$$

The number of observations (i.e. choice situations), and the size of the choice set (in terms of number of alternatives) may vary by individual. In principle, the choice set could also vary by choice situation (i.e. have different numbers of alternatives and/or attributes across choice sets offered) as well. For convenience, we allow y_{it} to denote the specific choice made, so that the model provides

$$P_{it \mid q}(j) = \text{Prob}(y_{it} = j \mid \text{class} = q). \tag{2}$$

For convenience, we also simplify this further to $P_{it \mid q}$. For the given class assignment, the contribution of individual i to the likelihood is the joint probability of the sequence $\mathbf{y}_i = [y_{i1}, y_{i2}, ... y_{iT}]$, given in (3).

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[1] Other studies by Hensher and his co-authors have focused on a single attribute processing rule (APR), and with the exception of Layton and Hensher (2008), have relied on process responses from supplementary questions to establish whether individuals adopted a specific APR (e.g. attribute addition or non-preservation).

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$$P_{i|q} = \prod_{t=1}^{T_i} P_{it|q} \qquad (3)$$

The class assignment is unknown. Let H_{iq} denote the prior probability for class q for individual i. A convenient form is the multinomial logit (MNL) (equation 4).

$$H_{iq} = \frac{\exp\left(\mathbf{z}_i'\mathbf{\theta}_q\right)}{\sum_{q=1}^{Q} \exp\left(\mathbf{z}_i'\mathbf{\theta}_q\right)}, \ q = 1,...,Q, \mathbf{\theta}_Q = \mathbf{0}, \qquad (4)$$

where $\mathbf{z}_i$ denotes a set of observable characteristics that enter the model for class membership. Roeder et al. (1999), using this same formulation, denote $\mathbf{z}_i$ the 'risk factors.' The Qth parameter vector is normalized to zero to secure identification of the model. The likelihood for individual i is the expectation (over classes) of the class specific contributions given in (5);

$$P_i = \sum_{q=1}^{Q} H_{iq} P_{i|q}. \qquad (5)$$

The log likelihood for the sample is

$$\ln L = \sum_{i=1}^{N} \ln P_i = \sum_{i=1}^{N} \ln\left[\sum_{q=1}^{Q} H_{iq}\left(\prod_{t=1}^{T_i} P_{it|q}\right)\right]. \qquad (6)$$

Maximization of the log likelihood with respect to the Q structural parameter vectors, $\mathbf{\beta}_q$ and the Q-1 latent class parameter vectors, $\mathbf{\theta}_q$ is a conventional problem in maximum likelihood estimation. For a given choice of Q, the choice of good starting values seems to be crucial. The asymptotic covariance matrix for the full set of parameter estimators is obtained by inverting the analytic second derivatives matrix of the log likelihood function.

Given the parameter estimates of $\mathbf{\theta}_q$, the prior estimates of the class probabilities are $\hat{H}_{iq}$. Using Bayes theorem, we can obtain a posterior estimate of the latent class probabilities using equation (7)

$$\hat{H}_{q|i} = \frac{\hat{P}_{i|q}\hat{H}_{iq}}{\sum_{q'=1}^{Q} \hat{P}_{i|q'}\hat{H}_{iq'}} \qquad (7)$$

The notation $\hat{H}_{q|i}$ is used to indicate the person-specific estimate of the class probability, conditioned on their observed dependent variables y_i, as distinct from the unconditional class probabilities which enter the log likelihood function. A strictly empirical estimator of the latent class within which the individual resides would be that associated with the maximum value of $\hat{H}_{q|i}$. To account for possible heuristics defined in the domains of attribute non-attendance, aggregation and common-metric parameter transfer, we impose restrictions on parameters within each latent class, each class representing a particular process heuristic. For example, to impose the condition of non-attendance of a specific attribute we set its parameter to zero; to impose common-metric aggregation we constrain two parameters to be equal; and to allow for parameter transfer we define a single parameter based on the parameter associated with a specific attribute[2].

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[2] The model estimated herein required modification of the code in Nlogit4.

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In the next sections we set out the empirical context and then estimate a latent class MNL model, comparing it with the traditional MNL model.

3.   Empirical application

The data are drawn from a study undertaken in Sydney in 2004, in the context of car driving commuters making choices from a range of level of service packages defined in terms of travel times and costs, including a toll where applicable. To ensure that we captured a large number of travel circumstances and potential attribute processing rules, we sampled individuals who had recently undertaken trips of various travel times, in locations where tollroads currently exist.[3] In addition, to also ensure some variety in trip length, an individual was assigned to one of the three trip length segments based on a recent commuting trip: no more than 30 minutes, 31 to 60 minutes, and more than 61 minutes (capped at two hours). A telephone call was used to establish eligible participants from households stratified geographically, and a time and location agreed for a face-to-face computer aided personal interview (CAPI).

A stated choice (SC) experiment was designed using principles of statistically efficient designs (Kanninen (2002), Sandor and Wedel (2002), Rose and Bliemer (2007), and Kessel et al. (2006) provide overviews of such design methods). Given a set of attributes and attribute levels, an *efficient* design is constructed such that the levels are allocated to the design in such a way that the elements (or subsets thereof) of the variance-covariance (VC) matrix are expected to be minimised once data is collected. Rather than work with the elements in the VC matrix directly, the literature suggests working with different measures that summarise the values that populate the VC matrix. One such measure is the D_p-error, which is given as

$$\left(I(\beta)^{-1} \right)^{\frac{1}{k}},\tag{8}$$

which is the determinant of the inverse of the Fisher Information matrix, I, for a design given a particular econometric model form and certain parameter estimates, β, scaled by one over the number of parameters, k. That is, the VC matrix of the model is calculated for the set of parameter estimates obtained for that model. In order to calculate equation (8) for our design, we had to assume a set of prior parameter estimates. These prior parameter estimates are drawn from Bayesian distributions and used to calculate the Bayesian D-error statistic, D_b-error, which is represented as

$$E_\beta \left[\det \left(I(\beta)^{-1} \right)^{\frac{1}{k}} \right] = \int_k \det \left(I(\beta)^{-1} \right)^{\frac{1}{k}}.\tag{9}$$

To generate a D-*efficient* design, different attribute level allocations were tested, with attribute level combinations that produce lower D-error values representing more statistically *efficient* designs. Such designs are expected to produce data that will maximise the *t*-ratios for the design parameters. In the current context, a D_b-efficient designs was generated in which parameter priors were obtained from previous studies involving similar design attributes, in particular from Hensher and Greene (2003). The precise method used to construct the experimental designs is discussed in Rose et al. (2008).

The two stated choice alternatives are unlabelled routes. We pivoted the choice experiment attribute levels around a reference alternative in recognition of supporting theories in behavioural and cognitive psychology and economics such as prospect theory, case-based decision theory and minimum-regret theory (Gilovich et al. 2002, Starmer 2000). The trip attributes associated with each route are free flow time, slowed down time, trip time variability, running cost and toll cost. All attributes of the stated choice (SC) alternatives are based on the

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[3] Sydney has a growing number of operating tollroads; hence drivers have had a lot of exposure to paying tolls.

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values of the current trip. Variability in travel time for the current alternative was calculated as the difference between the longest and shortest trip time provided in non-SC questions. The SC alternative values for this attribute are variations around the total trip time. For all other attributes, the values for the SC alternatives are variations around the values for the current trip. The variations used for each attribute are given in Table 1.

Table 1: Profile of the Attribute range in the SC design

	Free-flow time	Slowed down time	Variability	Running costs	Toll costs
Level 1	- 50%	- 50%	+ 5%	- 50%	0%
Level 2	- 20%	- 20%	+ 10%	- 20%	+ 20%
Level 3	+ 10%	+ 10%	+ 15%	+ 10%	+ 40%
Level 4	+ 40%	+ 40%	+ 20%	+ 40%	+ 60%

The stated choice questionnaire presented respondents with the sixteen choice situations, derived from the experimental design, each giving a choice between their current (reference) route and two alternative routes with varying trip attributes. An example of a stated choice screen (repeated 16 times with different levels of the attributes for Road A and Road B) is shown as Figure 1. The design has no dominance given the assumptions that less of all attributes is better.[4] The distinction between free flow and slowed down time is designed to promote the differences in the quality of travel time between various routes – especially a tolled route and a non-tolled route, and is separate to the influence of total time. Free flow time is interpreted with reference to a trip at 3 am in the morning when there are no delays due to traffic.[5] The sample of 243 effective interviews, each responding to 16 choice sets, resulted in 3,888 observations for model estimation.

Figure 1: An example of a stated choice screen

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[4] The survey designs are available from the first author.

[5] This distinction does not imply that there is a specific minute of a trip that is free flow per se but it does tell respondents that there is a certain amount of the total time that is slowed down due to traffic etc and hence a balance is not slowed down (i.e., is free flow like one observes typically at 3am in the morning).

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4. Empirical results

The latent class model considered a large number of candidate processing heuristics within the family domain of attendance, aggregation and parameter transfer. The final model (Table 2) has eight latent classes, of which five relate to attribute non-attendance, one to common-metric aggregation and two to common-metric parameter transfer. The overall goodness-of-fit is significantly better (i.e., -2503.82) than the traditional MNL model (i.e., -3033.93) and the mixed logit model (-2763.64) in which all attributes are assumed to be full preserved and hence relevant. The MNL model and the mixed logit model would be rejected in favour of the latent class MNL model on the standard likelihood ratio test with 17 (i.e., 21-4) degrees of freedom. In the LCM model, all but one parameter is statistically significant at the one percent level of significance or better, with free flow time under 'non-attendance of slowed down time' significant at the 10 percent level.

The empirical CDF of the posterior class membership probabilities, according to equation (7), is shown in Figure 2 (noting that the 8 classes defined from left to right at the top of Figure 2 are the equivalent classes to those listed in Table 2). The probability of membership in a class where all attributes are attended to is 0.2817 (Table 2). In contrast, the probability of membership in a class where one attribute is not attended to is 0.2122, and 0.26189 where one or two attributes are not attended to. The probability of membership in the class where the two travel times are added up is 0.2978. Finally, the two classes defining the parameter transfer rule have a total probability of membership of 0.15865. On this evidence, there is a good spread of processing rules, with the traditional full relevance of each attribute occurring up to a probability of 0.2817. What this suggests is that the classical full compensatory weighted additive alternative-based processing rule is applicable in one out of four circumstances. The new rules appear to apply in the ratio of 0.26:0.29:0.16.

Table 2: Empirical findings for MNL and latent class process models

(t-ratios in brackets) 3,888 observations (t-ratios in brackets)

NAT = not attended to ParT = parameter transfer	Class membership probability	Free flow time (minutes)	Slowed down time (minutes)	Running cost ($)	Toll cost ($)
Traditional MNL	1.00	-0.066376 (-17.64)	-0.08921 (-28.62)	-0.30834 (-14.35)	-0.36829 (-29.68)
Mixed Logit	1.00	-0.09840 (16.75)	-0.11821(20.74)	-0.40994 (14.58)	-0.52780 (22.76)
Latent Class Model:					
Non-attendance:					
All attributes attended to	0.2817 (5.5)	-0.07919 (-4.95)	-0.13341 (-12.5)	-0.7891 (-12.7)	-0.83382 (-17.9)
Free flow NAT	0.1119 (4.8)	-	-0.05173 (-10.9)	-0.1947 (-4.90)	-0.0988 (-5.70)
Toll cost NAT	0.0359 (1.6)	-0.07572 (-2.96)	-0.17079 (-8.80)	-1.1477 (-7.94)	-
Slowed down time NAT	0.0643 (2.6)	-0.0411 (-1.92)	-	-1.7673 (-9.27)	-1.8929 (-10.19)
Running cost and slowed down time NAT	0.0497 (2.1)	-0.4787 (-9.92)			-0.6808 (-8.23)
Aggregation:					
Free flow and slowed down time added	0.2978 (5.6)	-0.1898 (-30.14)		-0.2976 (-8.39)	-0.3071 (-16.9)
Parameter transfer:					
Free flow to slowed down and slowed down to free flow ParT	0.0758 (3.0)	-0.6150 (14.68)		-0.7891 (-12.7)	-0.8338 (-17.9)
Free flow to slowed down ParT and running cost to toll cost and vice versa ParT	0.0829 (3.4)	-0.6515 (-14.68)		-0.3986 (-12.08)	
Log-likelihood (0)		-4271.41			
Log-likelihood (converge) MNL (Mixed Logit)		-3033.93 (-2763.64)			
Log-likelihood (converge) Latent Class		-2503.82			

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An important finding is that the cost components have a low probability of not being attended to (i.e. $0.0359 + 0.0497$); however they also have a similar probability of being retained but with the parameter of toll cost being transferred to running cost (i.e., 0.0829). The evidence suggests that the slowed down time parameter is transferred to free flow travel time with a probability of 0.1586.

Processing Strategies
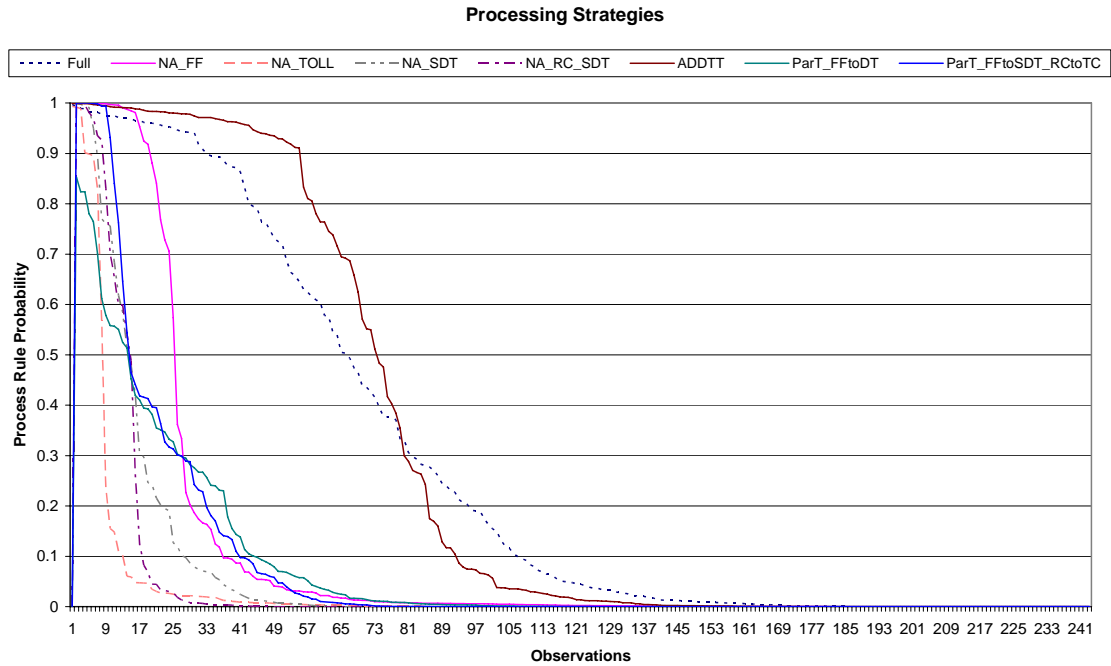
Figure 2 Class membership profile

The primary focus of this paper is to establish the implications of process heterogeneity on the marginal willingness to pay for each component of travel time and overall travel time. The findings are summarized in Table 3. As expected, there is a range of mean estimates of the value of travel time savings (VTTS) across the latent classes. The range is \$1.35 to \$42.19, after dividing the marginal disutility of each time component by the weighted average cost parameter, where the weights are the levels of running and toll cost. To obtain an overall sample average, we have to weight each mean estimate by the probability of class membership. The overall sample weighted average for total time is \$19.62, which contrasts with \$14.07 for the classical MNL specification and \$15.67 for mixed logit. The mean estimate of VTTS is 39.4 percent higher than MNL and 25.42 percent higher than mixed logit when process heterogeneity is accounted for across three classes of heuristics. The standard errors have been obtained by bootstrapping. The mean standard deviations for MNL, Mixed Logit and Latent Class are respectively \$1.42, \$3.71 and \$5.10. We can reject the null of no difference between LC and MNL and between LC and mixed logit but not between MNL and mixed logit.

A closer look at the contribution of each heuristic suggests that attribute addition for the two time components produces the highest mean estimate contribution to VTTS after controlling for class membership. Ignoring free flow time is the next contributor, followed by full attendance to all attributes. Ignoring running cost and slowed down time is the next contribution.

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Table 3: Values of travel time savings

(2004$ per person hour car commuter driver, standard deviations in brackets)

NAT = not attended to ParT = parameter transfer	Class membership probability	Free flow time	Slowed down time	Total time	Ranking of class membership scaled VTTS
Traditional MNL		11.76	15.72	**14.07 (1.42)**	
Mixed Logit		14.11	16.78	**15.67 (3.71)**	
Latent Class Model:					
All attributes attended to	0.2817	5.87	9.89	8.22	3
Free flow NAT	0.1119		23.02	23.02	2
Toll cost NAT	0.0359	3.95	8.93	6.85	7
Slowed down time NAT	0.0643	1.35		1.35	8
Running cost and slowed down time NAT	0.0497	42.19		42.19	4
Free flow and slowed down time added	0.2978		37.57	37.57	1
Free flow to slowed down ParT	0.0758		4.57	4.57	6
Free flow to slowed down ParT and running cost to toll cost ParT	0.0829		9.26	9.26	5
Class membership weighted VTTS				**19.62 (5.10)**	

To gain further insights into the findings, we considered the empirical evidence from the supplementary self-stated response questions on whether particular attributes were ignored and added up. We find that 9.88 percent ignored free flow time, 11.52 percent ignored slowed down time, 27.9 percent ignored running cost, and 15.63 percent ignored the toll cost. 88.1 percent added up the time components. Overall, 53.9 percent of the sample attended to all attributes. If we isolate the attendance/non-attendance class membership, we find that the probability of attending to all attributes is 0.518, which is encouragingly close to the self-stated proportion. Furthermore, although it appears that individuals who attended to both time components, tended in the main to add them up, a cross tabulation of addition or otherwise against the non-attendance of each time component, produced inconsistent responses[6] (see Hess and Hensher 2008 for more details)[7]. This raises a concern about the reliability of the self-stated responses. This may in part be attributable to the potential ambiguity of supplementary questions. For example, we are of the opinion that when someone states that they added up two attributes, they may be adopting a parameter transfer rule as distinct from an attribute addition rule. The issue of supplementary question clarity is a topic for further research. In the meantime, we reserve judgement as to whether the two ways of identifying the presence of process rules vary systematically; current 'evidence' suggests they do not map very well.

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[6] It is reasonable to expect that if there are two attributes that are added up, then one or both should not be ignored.

[7] A referee suggested that it would be interesting to see whether the respondents seem to do what they claim to do. A straightforward way to do this is to run the LC model with indicators of these responses as predictors z_i of class membership. The findings suggested that there is a very weak relationship between the class membership findings from the LCM model and what eac individual actually stated in regards to aggregation and attribute non-preservation. Many models resulted in 'estimated variance matrix of estimates is singular'. We managed to estimate some models with just one of the candidate processing rules at a time (e.g., add costs or add times, or ignore a specific attribute); but without exception the parameters were statistically non-significant. This is an interesting finding in itself.

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5.   Conclusions

This paper brings together an accumulating set of processing rules that are hypothesized to be applied by respondents assessing choice scenarios in stated choice experiments. The rules are ways of cognitively rationalising the information on offer in order to make a choice. Consistent with real market processing where individuals do not adopt a total preservation or all-attributes-are-relevant decision paradigm, we find in the latent class specification that is not contaminated by self-stated process advice that there is a probability in excess of 0.74 that a sample respondent will not adopt a strictly weighted additive alternative-based processing rule in making a choice.

The empirical evidence herein reinforces the evidence presented in Hensher and Layton (2008) and Hensher (2008a) that failure to identify and account for process heterogeneity tends to results in under-estimates of the marginal willingness to pay for travel time savings. If this evidence accumulates, and is shown to be applicable to a wider set of marginal willingness to pay attributes and contexts, then we should be concerned about the evidence, especially in an economic appraisal and demand forecasting context.

Tangential to the current study is the literature on hypothetical bias in stated choice studies, which suggests that the marginal WTP is under-estimated for VTTS in stated choice studies compared to actual market-based evidence by as much as 50 percent (see Brownstone and Small and Hensher 2008b). Isacsson (2007), in the context of trading time with money, found that the marginal WTP based on a hypothetical experiment was almost 50 percent lower at the mean than the real experiment marginal WTP, supporting the conclusions by Brownstone and Small (2005) in a transport context that "…the value of time saved on the morning commute is quite high (between \$20 and \$40 per hour) when based on revealed behavior, and less than half that amount when based on hypothetical behavior" (page 279). It may be that the failure to accommodate process heterogeneity is a major contributing influence, given the 39.4 percent higher mean VTTS herein when processing rules are accounted for. Theses studied all ignore the possibility in real markets that individuals use a range of attribute processing heuristics in evaluating available options[8].

In ongoing research, encourage further investigation of the LCM framework presented herein, to assess (i) the possible nonlinearity of the parameters (or asymmetry in preferences) given a pivot or reference-based choice experiment, (ii) the role of different self-stated response questions as a way of gaining further understanding of the plausibility (or believability) of such responses, and (iii) other heuristics than might condition choice outcomes.

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[8] Hensher (2008) has concluded that: "This approach to seeking out improved ways of capturing the way in which individuals process stated choice experiments and make outcome choices is consistent with arguments being promoted in behavioural and psychological theories of how individuals make choices in real markets."

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