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Unravelling theory in choice analysis: do consumers fill in the blanks?

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Abstract

Unravelling theory postulates that consumers assume products without quality information are of the lowest quality. In a discrete choice experiment (DCE) with 1987 respondents from the UK, we find evidence against this assumption. Affirmative disclosure, which indicates only quality above the lowest level, lowers marginal utilities compared to complete disclosure. The development in food choice DCE studies, from textual and complete towards visual and affirmative increases mean willingness to pay and error variance. This suggests that analysts should carefully consider how attributes are presented when designing DCEs to avoid biased welfare estimates, especially when aiming for accurate market predictions or policy advice.

Keywords: unravelling theory, unfolding theory, attribute representation, discrete choice analysis, choice experiment, information processing, welfare estimates

1. Introduction

Discrete choice experiments (DCEs) enable the elicitation of consumer preferences and willingness to pay for attributes of consumer goods, and this method is particularly useful for investigating attributes or products that are not available on the market (Louviere, Hensher and Swait, 2000). Respondents in DCEs are presented with the task of selecting their most preferred alternative among several alternatives, each described by its attributes. The utility from each alternative comprises the sum of the marginal utilities from each of the attributes (Lancaster, 1966). Utility maximizing individuals thus reveal their preferences through their choices. The foundation in economic theory makes the DCE an

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attractive method for analysing demand and the marginal importance of specific attributes, and it has gained wide popularity in the field of food economics in the past two decades (Caputo and Scarpa, 2022).

Experimental methods facilitate high degrees of experimenter control and thus internal validity, but they are typically associated with challenges regarding external validity (Roe and Just, 2009). This concerns the extent to which results from a study can be generalized to other persons, contexts or times, and one source of external validity is ecological validity, which relates to the extent results would hold in a naturalistic environment (Haghani *et al*., 2021). Applications of DCEs in general, and in the context of food in particular, have developed in the direction of increased ecological validity. Early applications of food DCEs presented alternatives (food products) as columns in a table, where each attribute was described textually [see for example Brooks and Lusk (2010) and Carlsson, Frykblom and Lagerkvist (2005)]. More recently, the presentation mode has evolved towards formats that more closely mimic real purchase situations, where the product is presented with a picture and the attributes are presented with labels or logos similar to real food products [see for example Edenbrandt and Lagerkvist (2021) and Peschel and Grebitus (2023)]. Importantly, contrasting the early applications of textual presentation in tables with more recent variants with visual presentation of labels implies differences in two dimensions. First, they vary in the format of presentation, with textual versus visual forms. Second, they differ in how they disclose information about the lowest level of quality for attributes. Labels and logos are typically only present when a product fulfils the requirements of the higher quality, while leaving the space blank if the criteria are not fulfilled. Notably, the presentation of attributes in DCEs varies between studies, and commonly also between attributes in the same study. The important question arises whether behaviour can be expected to be independent of the format used to present attributes. If welfare estimates are influenced by the mode of attribute presentation, this has implications for interpreting results from DCE-based consumer research and is crucial for designing future studies. This is particularly important since welfare estimates obtained from DCEs may inform policy decisions (Sunstein, 2021), and biases in these estimates could lead to inaccurate conclusions. The aim of this study is to investigate whether disclosure of attribute information affects estimated marginal utilities in DCE studies.

In economic theory, it is typically suggested that in the absence of costs for providing information, all producers, excluding those with the lowest quality, will reveal the quality of their products. We label this *affirmative* information disclosure, when only products with quality above the lowest level are indicated. In contrast, *complete* information disclosure implies that all products, including the lowest quality level, are indicated. Unravelling theory postulates that when there is no information about a quality attribute, consumers will assume the lowest level of quality (Grossman, 1981; Ippolito and Mathios,

1990) .[1] As an example, a product that does not carry an organic label will be assumed by consumers to be conventionally produced. If this assumption holds true, there will be no differences in results if a DCE specifies non-organic alternatives as 'conventional' or if this level is left blank in the presentation of the alternatives. However, the question is if consumers in general can be assumed to be this sophisticated (Loewenstein, Sunstein and Golman, 2014). The first objective of this study is to investigate if the assumption of unravelling theory holds true in DCEs, or if marginal utilities for product attributes depend on the information disclosure format.

Presenting products in a more realistic format, by presenting attributes with existing or fictitious labels and logos implies a movement away from complete disclosure and textual presentation, and a key question is thus what the total effect is from this movement. While unravelling theory suggests no impact on marginal utilities from disclosure format, failure by individuals to fill in the blanks implies *lower* marginal utilities when moving from complete to affirmative disclosure. However, the movement from textual to visual presentation of attributes is expected to result in *higher* marginal utilities.

Visual presentation of information, in the form of labels and logos, implies greater salience compared to textually presented information. Research using eye-tracking measures has confirmed that greater salience is associated with more visual attention (Pieters and Wedel, 2004) and there is evidence of a positive association between attention and preferences in the context of food choices (Van Loo *et al*., 2018; Bansal, Kim and Ozdemir, 2024). This suggests that visually presented attributes will receive more attention and exhibit larger marginal utilities compared to textually presented attributes. Taken together, when moving from complete to affirmative disclosure, the change from textual to visual presentation of attributes could potentially be a remedy for the divergence resulting from change of disclosure format. The second objective of this study is to investigate the total effect on welfare estimates from moving from textual presentation and complete disclosure towards visual presentation and affirmative disclosure.

The strength of DCEs is that they mimic real-world tasks that consumers face when purchasing food. Presenting attributes in a format that is as similar as possible to the market situation, by displaying labels and logos, increases the ecological validity of the experiment. Yet, an important reason for conducting DCEs is that they allow the investigation of preferences for attributes or attribute levels that are not available on the market (Caputo and Scarpa, 2022). In these situations, there are usually no existing labels or logos for these attributes or attribute levels. This may explain why the presentation of attributes in DCEs varies between studies and notably also between attributes in the same studies. This study contributes insights regarding whether efforts to increase ecological validity come at the expense of biased estimates in DCEs.

1 We limit the discussion to qualities that are vertically differentiated, where all consumers have the same order of preferences for the quality, while there may be heterogeneity in preference strength (McCluskey and Winfree, 2022).

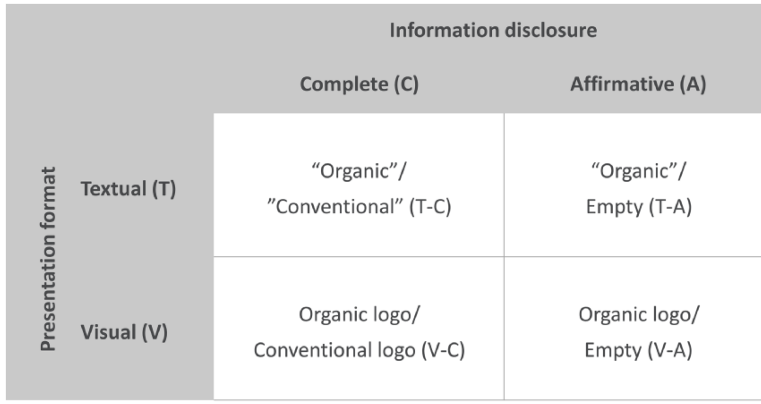

Fig. 1. Information disclosure and presentation of attributes in DCEs.

The findings from this study should inform about the effects on welfare estimates from using different disclosure formats. We do so in a between-subject DCE design with 1,987 respondents in the UK. Our results provide insights on the effects of attribute disclosure and how this interacts with presentation format, which is valuable for interpreting existing DCE research and provides guidance in the design of future DCE consumer studies.

The paper is organized as follows. The next section provides a background on how attributes in DCEs are presented, while Section 3 presents the theoretical framework used to investigate the research questions. Section 4 outlines the empirical application and Section 5 presents the results. Section 6 closes with a discussion of the findings and concludes with the contributions of the study and directions for future research.

2. Background on attribute presentation in DCEs

With the two dimensions of information disclosure (affirmative vs. complete) and presentation format (visual versus textual), four possible combinations are possible, as depicted in Fig. 1. We use organic production method as an example attribute to illustrate each combination. Attributes that are presented textually and where each quality level is described were initially the typical condition in DCE studies, and this is represented in the top-left cell in Fig. 1: the information is textual (T) and the disclosure format is complete (C). Recent examples of studies applying the T–C condition include Caputo et al. (2018), where the absence of a label (organic, animal welfare, free-range claim, reduced carbon footprint) is indicated with the text 'No label' and Ortega et al. (2020), where the lowest quality levels are indicated with 'genetically modified' and 'non-traceable'.

In the textual-affirmative (T-A) condition (top right cell in Fig. 1), attributes are presented textually, and the lowest quality level is left empty. Chenarides

et al. (2022) provides an example where all attributes are presented in text, including 'locally grown' and 'USDA Organic' and where the space on the choice card is left empty on products that do not display these quality labels.

Presenting attributes visually and by complete disclosure (V-C) is less common in the DCE literature. One example is Huang et al. (2021), where the lowest quality is presented with a crossed over quality logo to indicate the absence of the quality label.

Finally, the V-A condition implies that products that fulfil the requirements of a label display such a logo on the package in the choice tasks, while products that do not fulfil these requirements present no information on this attribute, and this is typically the condition in real world food purchase situations. An application of the V-A condition is Peschel and Grebitus (2023), where attributes such as 'Red tractor' and 'No growth hormones' are presented as logos on pictures of meat, and products that do not fulfil the label requirements display no logo.

A desire to increase ecological validity may explain the increased use of visual presentation of attributes in food DCEs. Meanwhile, a key reason for applying DCEs is that it enables examination of preferences for attributes or attribute levels that are not yet available on the market, and where there are typically no existing labels or logos for these attributes or attribute levels available. This may explain why many studies apply a mix of presentation formats. For example, De Marchi, Cavaliere and Banterle (2022) present breeding technology as 'cisgenic' or 'conventional' (textual presentation + complete disclosure, T-C), while quality brand is presented by a logo or left empty (V-A). In Gerini, Alfnes and Schjøll (2016), all attributes have a textual presentation, while two of the four attribute levels on animal welfare are also accompanied by a visual logo. In Asioli, Bazzani and Nayga (2022) a carbon trust label is presented by a label or an empty space (V-A), antibiotics use is presented by 'No antibiotics ever' or an empty space (T-A), and production method ('Conventional' or 'IVM') is presented textually with complete disclosure (T-C). Scarpa et al. (2021) present origin of a wine by presence or absence of Italian flag (V-A), while taste is indicated by 'delicate taste'/'strong taste' (T-C). Lin, Ortega and Caputo (2023) use a mix of visual and textual presentation, while all attributes provide complete disclosure. Schwickert (2023) also applies a mix of conditions, with animal welfare in V-A format and country of origin in the T-C form. Kilders and Caputo (2024) use a labelled design, where the lowest quality alternative (conventional) is left empty, while the 'Lower Carbon Footprint' is presented textually and organic and animal welfare are presented visually with logos.

3. Theory

3.1. Unravelling theory and information disclosure

Unravelling theory implies that if there are no costs associated with providing information, firms with high quality products will voluntarily disclose information about their product's quality to distinguish themselves (Grossman,

1981; Viscusi, 1978). As this reasoning is applied iteratively, it results in a market where all but the lowest-quality products disclose their attributes. In the case of a 'negative' attribute, the unravelling process operates in reverse, driving disclosure from products with lower levels of the undesirable feature, resulting in the same outcome of full information transparency. Assuming that the information disclosure is credible, rational consumers will infer that when quality information is not disclosed, the product has the lowest quality (Ippolito and Mathios, 1990). Unravelling theory, also called 'unfolding theory', relies on the assumption that consumers are aware that the information exists, and that the quality in question is important to at least a portion of consumers. Importantly, it requires that consumers are sufficiently sophisticated to infer that the absence of quality information indicates the lowest level of quality (Ippolito and Mathios, 1990; Loewenstein, Sunstein and Golman, 2014). In DCEs, participants are typically assumed to fill in the blanks. However, if consumers lack awareness of this connection or fail to draw these conclusions, the form of information disclosure used in DCEs may affect the results.

In the analysis of categorical attributes included in DCEs, the marginal utility from an attribute level is estimated relative to the base level. Taking a binary attribute as an example, complete information disclosure implies that both the highest and lowest quality levels are disclosed ($q^{high} = 1$ and $q^{low} = 0$), and the estimated marginal utility for high quality relative to low quality is β^q. Following unravelling theory, the absence of information disclosure is interpreted as $q^{low} = 0$, but if individuals fail to make this inference, they will interpret $q^{high} \geq q^{low} > 0$. Thus, with sophisticated decision makers, the inferred quality for the lowest quality level is independent of information disclosure format. However, for unsophisticated decision makers the perceived level of quality for the lowest level depends on information disclosure format, such that $q^{low}_{affirmative} > q^{low}_{complete}$. We hypothesize that at least a share of individuals will not fill in the blanks, implying that the average marginal utility for a quality attribute is larger with complete disclosure compared to affirmative disclosure:

$$H1_0 : \left|\beta^q_{complete}\right| = \left|\beta^q_{affirmative}\right|$$

$$H1_A : \left|\beta^q_{complete}\right| > \left|\beta^q_{affirmative}\right|$$

It is important to note that for attributes that are perceived as negative by consumers, such as GMOs, information will be disclosed in reverse, indicating the absence of the bad quality (such as non-GMO). Negative attributes will only be disclosed under mandatory disclosure requirements. The effects of mandatory versus voluntary labelling schemes have been explored in the literature (Crespi and Marette, 2003; Costanigro and Lusk, 2014; Sunstein, 2017). While voluntary labelling implies an affirmative disclosure condition—emphasizing positive attributes—mandatory labelling schemes may follow a negative disclosure condition, providing information about the lowest quality level. Relating to this, Grankvist, Dahlstrand and Biel (2004) investigated the

impact of positive compared to negative information disclosure, suggesting that for individuals with intermediate interest in environmental issues, negative information disclosure regarding the products environmental impact had stronger effect on choices. However, both the negative and positive information were of the complete disclosure format, disabling insights on the effect of disclosure format. Insights on the impact of using affirmative compared to complete disclosure in DCEs are thus not provided.

Beyond the DCE setting, it has proved challenging to use market data to investigate if consumers correctly infer that unlabelled products are of the lowest quality. Instead, such investigations rely primarily on laboratory experiments. Results suggest the presence of both sophisticated consumers, who correctly infer that the absence of quality information signals the lowest quality as well as naïve consumers, who assume that the absence of disclosure indicates an average quality level (Jin, Luca and Martin, 2021; Deversi, Ispano and Schwardmann, 2021; Montero and Sheth, 2021).

3.2. Interacting affirmative disclosure with visual presentation

With the advancement in how attributes are presented in DCE studies, we set to examine how welfare estimates are influenced by the shift from textual presentation with complete disclosure towards visual presentation with affirmative disclosure. This will depend on the effects from moving from textual to visual presentation format as well as potential interaction effects with the information disclosure format. Regarding the effect of moving from textual to visual presentation, evidence from visual attention studies using eye-tracking measures have found that images and logos attract more attention than textual information (Pieters and Wedel, 2004; van Herpen and van Trijp, 2011). In the context of DCEs, there is evidence of a positive relation between attention and preferences (Bansal, Kim and Ozdemir (2024), suggesting larger marginal utilities for quality attributes in DCEs when presented visually compared to textually ($|\beta^{q}_{visua}| > |\beta^{q}_{textual}|$). An early study on this topic found that visual presentation of car stereos resulted in higher relative importance of attributes compared to when textual presentation format was used (Vriens *et al*., 1998). In the food choice context, Katz, Campbell and Liu (2019) find that visually presented attributes receive more attention, and that a locally grown attribute is valued higher when presented by a logo compared to text, while preferences for organic do not depend on presentation format. In an experimental auction study involving fruit producing plants, visual presentation results in greater attention and higher willingness to pay (WTP) estimates (Rihn, Wei and Khachatryan, 2019). DeLong et al. (2021) find the opposite association in a study on meat choices; WTP estimates are larger when attributes are presented textually rather than visually.

As described above, it can be expected that marginal utilities are smaller with affirmative compared to complete disclosure, while visual presentation is expected to imply larger marginal utility estimates compared to textual presentation. The effect on marginal utility estimates resulting from the movement

from textual presentation and complete disclosure towards visually presented and affirmative disclosure is not clear a priori. It will depend on which of the differences that are largest, as well as if there are any interaction effects:

$$H2_0 : \left|\beta^q_{textual+complete}\right| = \left|\beta^q_{visual+affirmative}\right|$$

$$H2_A : \left|\beta^q_{textual+complete}\right| \neq \left|\beta^q_{visual+affirmative}\right|$$

3.3. Choice consistency

Potentially, differences in how visually and textually presented attributes in DCEs are processed affect the consistency of choices. Dual coding theory describes two distinct information processing systems: the visual and the verbal. Visual stimuli are processed faster and more automatically and provide a more direct meaning and interpretation compared to verbal stimuli (Unnava and Burnkrant, 1991; Paivio, 1971). Visual information further evokes more emotional processing while textual presentation activates cognitive processing (Lee, Amir and Ariely, 2009). One possible scenario is that faster and more emotional information processing with visual attribute presentation implies less consistent choice behaviour. In the food context, this is supported in a best–worst study on wine, which finds higher variance when using visual packaging attributes compared to textual attributes (Mueller, Lockshin and Louviere, 2010). This is corroborated in the context of landscape choices (Shr *et al*., 2019) where randomness is larger when using visual presentation, and in Veldwijk et al. (2015), where the choice inconsistency is larger when alternatives of vaccines are presented visually rather than textually. Another possible scenario implies the opposite effect, as proposed by Lee, Amir and Ariely (2009), that emotional information processing results in more consistent choices, since emotions are less prone to change compared to logical reasoning. A DCE application find evidence to support this, showing lower error variance when attributes on meat alternatives are presented visually compared to textually (Uggeldahl *et al*., 2016). Given the contradicting theoretical predictions regarding the impact of visual compared to textual presentation formats on choice consistency, as measured by the relative scale in choice models (λ), we have no prior expectations about if this depends on the format of presentation ($\lambda_{visual} = \lambda_{textual}$). Additionally, since theory does not guide if there are differences in choice consistency depending on the information disclosure or presentation format, we will explore differences resulting from the movement from textual and complete disclosure to visual and affirmative disclosure without prior expectations:

$$H3_0 : \lambda_{textual+complete} = \lambda_{visual+affirmative}$$

$$H3_A : \lambda_{textual+complete} \neq \lambda_{visual+affirmative}$$

4. Methods

4.1. Empirical case study and data

Data were collected in an online survey, distributed to a UK consumer panel managed by TGM Research. The survey received ethical clearance by [University name omitted for remained anonymity]. Participation in the panel and in the survey was voluntary, and as compensation for their participation, respondents were rewarded points that can be transferred to vouchers by the panel firm. Upon invitation to the survey, respondents were informed about the broad topic of the survey (food preferences), and that they could withdraw at any point without giving a reason. Prior to answering the survey, participants gave their consent.

We applied quota sampling to match the UK population with respect to age and gender. Only respondents that indicated to be at least partially responsible for food purchases in their household were included, and those that never purchase the product used in the choice experiment were also excluded. To ensure data quality, the survey included an early attention screening question, where respondents failing to provide the correct response were discontinued. Respondents with a response time below 2.5 min were excluded from analysis, as testing prior to data collection deemed this an unrealistically fast response time if the respondents were to read the questions.

We used a between-subject design with four treatments, representing the 2*2 factors for information disclosure and presentation format (T-C, T-A, V-C and V-A). Following the initial screening question and a brief introduction to the choice experiment tasks, respondents were randomly assigned to one of the treatments. Following the choice tasks, there were follow-up questions regarding stated attendance to the attributes and a set of questions regarding meat attitudes and environmental values, not used in this study. Respondents were asked to provide feedback on their responses (‘In your honest opinion, should we use your responses, or should we discard your responses since you did not devote your full attention to the questions so far?’), and we excluded those that indicated that they thought their responses should be discarded since they had not paid attention (18 were excluded). In the final data set, there were 1,987 completed responses. Descriptive statistics of the sample are presented in Table A1 in the Online Appendix.

4.2. Experimental design

The DCE design was the same in all treatments, only the way of presenting the attributes varied. To facilitate investigation of differences between affirmative and complete disclosure, we settled to focus on binary attributes, where the product can either fulfil the requirements for a label or not. We note that it would be possible to include attributes with more levels, where only the lowest quality is left empty in the affirmative treatment, but we focus on binary attributes to obtain the most information from the experiment.

The product of the DCE was beef mince, and attributes were selected based on market analysis and a pilot study. The binary attributes included were: Low Carbon (LC), Premium Quality Angus (PQA), RSPCA (indicating higher animal welfare) and Fair to Nature (FTN) production practice to enhance biodiversity. Each of these attributes was briefly described prior to the tasks. In addition to the binary attributes, there was a continuous attribute indicating the fat content (5 per cent, 10 per cent, 15 per cent and 20 per cent) as this is a key attribute for many consumers. Price included eight levels (2.5–6.0 GBP with 0.5 increments). Finally, there was an option to not purchase any of the alternatives. The attributes and levels are presented in Table A2. Figure 2 depicts example choice tasks for each of the treatment groups.

The design included 24 choice tasks, which were divided in blocks of three to reduce the number of tasks for each respondent, such that each respondent was randomly assigned to one of the blocks. The design was generated in Ngene using a d-efficiency criterion, where moderate priors were used based on the pilot study and empirical studies using similar attributes. A short cheap talk script was included prior to each choice task. The order of presenting the alternatives in each task was randomized, and the order of the choice tasks was randomized. Following the choice tasks, there were follow-up questions regarding stated attendance to the attributes ('Which, if any, of the following food characteristics did you ignore when completing the choice tasks? You can tick none or as many as required)'). This was used in sensitivity analysis with the purpose of investigating differences is attribute non-attendance (ANA) across treatments. For the full survey, see our research box.

4.3. Modelling approach

To test the hypotheses, the choice data are analysed for each treatment group. Let the utility that individual n derives from product $i = 1,\ldots,J$ in choice task t be $U_{nit} = -\alpha p_{nit} + \beta' x_{nit} + \varepsilon_{nit}$. The cost attribute, p, and the vector of non-cost attributes $\boldsymbol{x}$ describe the products. The coefficients α and β are to be estimated, and ε are type I extreme value distributed error terms with variance $\sigma^2 = \pi^2/6\lambda^2$, where λ is a scale parameter that is normalized to unity. The taste coefficients are confounded with λ, which prevents direct comparison of parameters across samples (treatment groups). We reparametrize the utility function in WTP-space (Train and Weeks, 2005; Scarpa, Thiene and Train, 2008), such that $U_{nit} = -\gamma(p_{nit} + w' x_{nit}) + \varepsilon_{nit}$, where γ is the price-scale coefficient equal to α/λ and $\omega = \beta/\alpha$ are the mWTP coefficients for the attributes. When the individual makes repeated choices, the probability of the sequence of choices by individual n is $y_n = [i_{n1}, i_{n2}, \ldots, i_{nT}]$. Under these assumptions, the choice probability can be estimated by the multinomial logit (MNL) model (Train, 2009):

$$P(y_n|p_n, x_n) = \prod_{T_n}^{t=1} \frac{\exp\left(\gamma\left(p_{nit} + w' x_{nit}\right)\right)}{\sum_{j=1}^{J} \exp\left(\gamma\left(p_{njt} + w' x_{njt}\right)\right)} \tag{1}$$

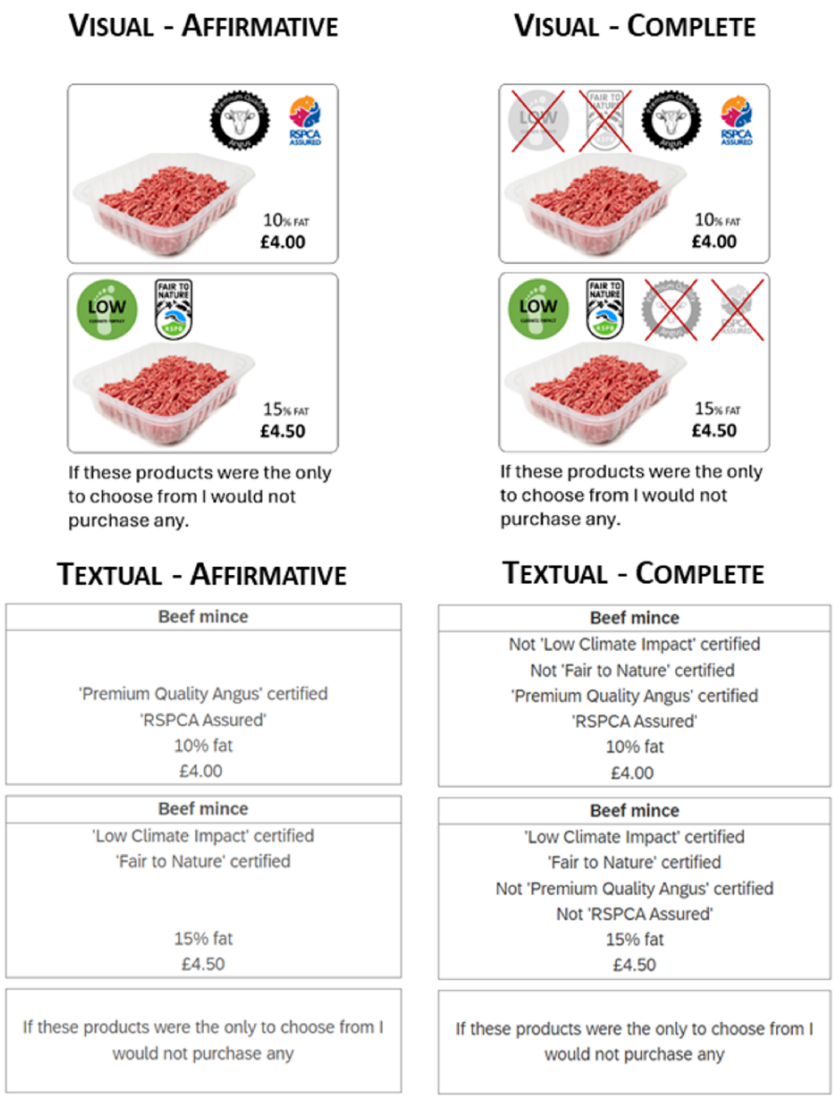

Fig. 2. Example choice tasks from each of the treatment groups.

Heterogeneity in preferences across individuals can be accounted for with a mixed logit (MXL) model specification by allowing random variation in the coefficients (Hensher, Rose and Greene, 2015). The random parameters of $[\alpha_n, \omega_{1,n}, \omega_{2,n}, \ldots, \omega_{K,n}]$ are described by a joint density denoted $f(\theta_n|\Omega)$ (Train, 2009). The unconditional probability of individual n's sequence of T

choices is:

$$P(y_n|p_n,x_n,\Omega) = \int \prod_{t=1}^{T_n} \frac{\exp\left(-\gamma_n\left(p_{nit} + w'_n x_{nit}\right)\right)}{\sum_{j=1}^{J} \exp\left(-\gamma_n\left(p_{njt} + w'_n x_{njt}\right)\right)} f(\theta_n|\Omega)\, d\theta \quad (2)$$

Models are estimated in R using the Apollo package (Hess and Palma, 2019). To reduce the likelihood of reaching local optima, we estimate each model with different start values and with increasing number of draws. The presented models used 1,000 sobol draws.

4.4. Model specification

5. We use a linear specification of the utility function

$$\begin{aligned} V_i =& \delta_i - \gamma(price_i + \omega_1 LowCarbon_i + \omega_2 FairToNature_i + \omega_3 RSPCA_i \\ &+ \omega_4 PQA_i + \omega_5 fat_i) + \eta_i \end{aligned} \quad (3)$$

where δ_i is an alternative-specific constant, indicating the utility for choosing no product (opt-out) relative to the first two alternatives, which are normalized to zero for identification purposes. Each of the Ω's are specified to take normal distributions and γ to take a negative lognormal distribution. An error component η_i is included in the utility function for the first two alternatives to take into consideration correlation patterns between the unobservable components of utility between these alternatives (Scarpa, Ferrini and Willis, 2005).

The mWTP for each attribute is compared across the models estimated on the different treatment groups, and tests for differences in mean mWTP between treatment groups are undertaken by the complete combinatorial approach (Poe, Giraud and Loomis, 2005). Differences in choice consistency in the treatments is tested by including the treatment groups in one model, while the scale for three of the treatment groups is estimated relative to one treatment, which is normalized to zero for identification purposes (Swait and Louviere, 1993).

In a set of sensitivity analyses, we compare the inferred attribute non-attendance (ANA) across treatments. As proposed in Hess and Hensher (2010), the conditional parameters, based on the sequence of choices made by the individuals, are retrieved. The coefficient of variation, which is the ratio between the standard deviation and the mean, indicates the noise to value ratio, and values above two indicates ANA.

6. Results

Accommodating random heterogeneity in MXL models shows highly significant improvements in model fit compared to MNL specifications for all treatment groups. Table 1 reports results for the MXL models for each of the treatments while results for the MNL models are presented in Table A3.[2] In

2 Data and code for all analysis are available at our researchbox.

all four models, the mWTP coefficients are of the expected sign, and they are statistically significantly different from zero. On average, individuals are willing to pay more for products that are labelled as better for the climate (LC), higher animal welfare (RSPCA), environmentally friendly (FTN) and of premium quality (PQA). The RSPCA is the most important attribute followed by quality and environment, while low carbon impact is the least important. Individuals obtain disutility from not selecting a product, and the unobserved parts of the utilities for the product alternatives are correlated. The size of the standard deviations relative to the mean estimates implies that there is largest heterogeneity in mWTP for low carbon emissions and fat.[3] We note that for fat content this is likely attributed to differences in taste (some may find higher fat content to be tastier, but it may also be less healthy). For low carbon, the heterogeneity is likely rather driven by a share of individuals that are close to indifferent to this attribute, while others have a positive WTP. In the remainder of the analysis our focus will be on the four binary attributes that vary between the treatments.

6.1. Affirmative vs. complete information disclosure

To investigate the first hypothesis, we test for differences in mWTP between the affirmative and complete disclosure. We test this separately for when the attributes are presented visually and textually, such that we compare treatment T-C with T-A and treatment V-C with V-A. Likelihood ratio tests between models where the treatments are pooled and estimated separately suggest that the preference structure is significantly different in the affirmative and complete treatment groups. Pooled models and details on likelihood ratio tests are presented in Table A5.

Comparisons between complete and affirmative disclosure, when textual presentation format was used, are presented in the top panel in Fig. 3. For all four attributes that vary between the treatments, the mWTP is higher for the complete disclosure compared to the affirmative disclosure. The differences are statistically significantly different for RSPCA and FTN at the 5 per cent level and for LC at 10 per cent level. Results are similar when comparing affirmative and complete disclosure when the information is displayed visually (bottom panel Fig. 3), where the differences are statistically significantly different for all four attributes at the 5 per cent level. These findings are in line with H1. The mWTP for fat is not different in the affirmative and complete disclosure treatments, which is to be expected, since this attribute does not vary between the treatments.

6.2. Interacting affirmative disclosure with visual presentation format

To explore the effects from moving from complete disclosure and textual presentation to affirmative disclosure and visual presentation, we start by testing if

3 The share with positive mWTP for each attribute is presented in Table A4.

Table 1. Estimates of MXL models in WTP-space by treatment group

		T-C		T-A		V-C		V-A	
# ind./ #choices		497	3,976	503	4,024	496	3,968	491	3,928
LL		−2,990		−2,788		−2,567		−2,414	
		Est.	|*t*-ratio|	Est.	|*t*-ratio|	Est.	|*t*-ratio|	Est.	|*t*-ratio|
RSPCA	ω	1.34	7.45	0.80	7.89	1.42	10.61	0.77	8.25
	σ	1.31	5.44	0.66	2.21	1.12	5.23	0.17	0.70
FTN	ω	0.80	5.93	0.38	4.49	0.98	8.73	0.31	3.50
	σ	1.10	3.65	0.24	1.17	1.12	5.35	0.76	3.73
PQA	ω	0.83	7.65	0.71	7.69	1.00	9.15	0.57	6.26
	σ	0.18	0.46	0.52	2.91	0.37	−0.38	0.33	1.10
LC	ω	0.38	3.28	0.16	1.72	0.54	5.17	0.25	2.30
	σ	0.99	4.74	1.07	5.61	1.26	6.02	1.28	5.25
Fat	ω	−0.16	6.67	−0.16	−7.70	−0.20	8.94	−0.16	7.54
	σ	0.29	8.16	0.26	10.78	0.29	10.05	0.28	9.13
Price-scale	ln(γ)	−0.59	6.30	−0.44	6.08	−0.38	4.30	−0.24	3.32
	σ	0.61	4.13	0.59	12.35	0.55	7.39	0.70	10.21
Opt-out	δ	−6.06	12.71	−8.02	16.56	−9.98	9.49	−12.07	8.94
EC	σ	3.43	5.76	3.04	11.87	4.91	6.43	4.42	6.58

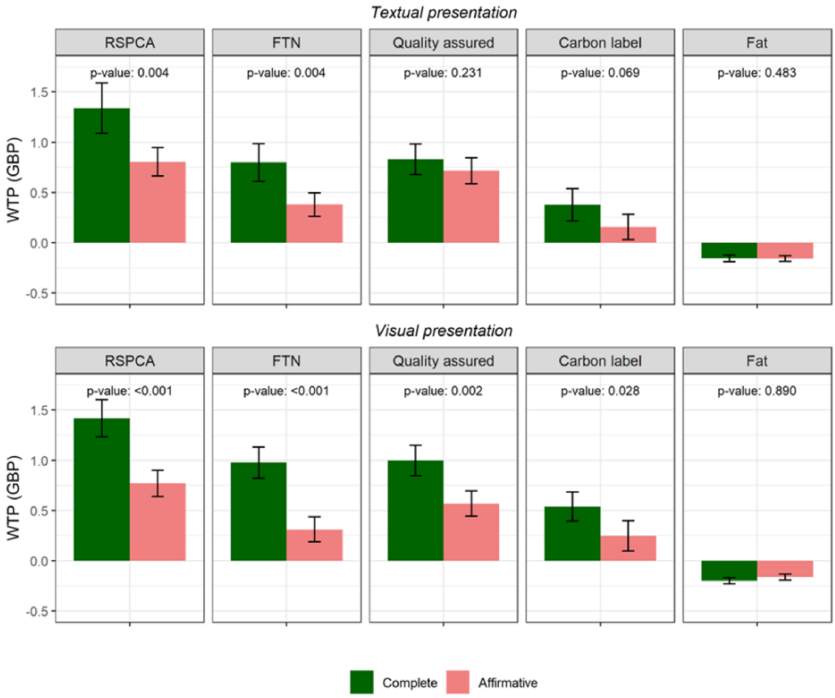

Fig. 3. Marginal WTP for attributes in complete versus affirmative disclosure treatments.
Note: *P*-values from poe-tests, where values >0.95 or < 0.05 indicate different mean mWTP at the 5 per cent level of confidence. Eighty-three per cent CI are reported. To accommodate tests for differences in means by comparing overlapping confidence intervals, CI should be approximately 83 per cent. CI of 95 per cent implies a considerably more conservative test (≈ 99 per cent level of confidence) (Payton, Greenstone and Schenker, 2003).

there are differences in mWTP estimates for textually versus visually presented attributes. There are no statistically significant differences between textual and visual treatments for any of the binary attributes. While the pattern for the complete disclosure comparison indicates somewhat higher mWTP with visual presentation, these are not statistically significant. For the affirmative disclosure comparison, there are barely any differences. Results are presented in Figure A1, while pooled models and likelihood ratio tests are available in Table A5.

Following the second hypothesis, we investigate if there are differences in mWTP between complete disclosure and textual presentation (T-C) and affirmative disclosure and visual presentation (V-A). Overall, the V-A treatment shows lower mWTP estimates for all binary attributes compared to the T-C treatment (Fig. 4), and the differences are statistically significant at the 5 per cent level for RSPCA, FTN and PQA. Thus, the significant reduction in mWTP from using affirmative rather than complete disclosure (Fig. 3) remains when changing from textual to visual presentation format.

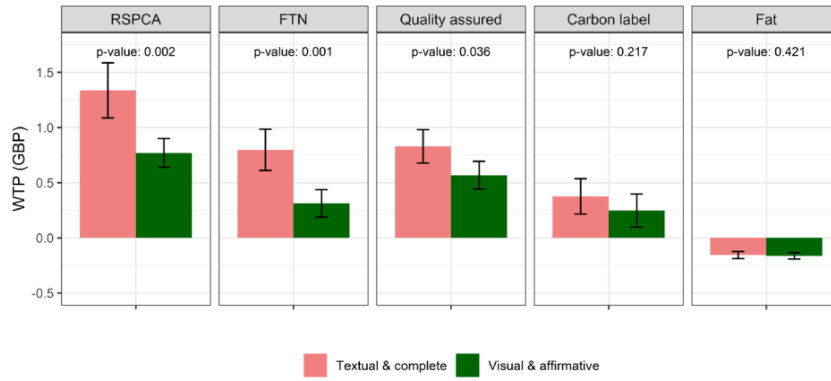

Fig. 4. Marginal WTP for attributes in textual-complete versus visual-affirmative treatments.
Note: *P*-values from poe-tests. Eighty-three per cent CI are reported.

To explore if there are differences in choice consistency when moving from the textual presentation with complete disclosure to visual presentation with affirmative disclosure, we estimate a pooled model where all four treatments are included while controlling for differences in scale. The T-C treatment is used as the reference level ($\lambda_{\mathrm{T-C}} = 0$). First, we observe that the relative scale is larger in the visual compared to the textual treatments. This finding holds when we test for differences in scale between the visual and textual treatments in pooled models while separating by complete and affirmative disclosure. See full results in Table A5 with supplementary notes. Furthermore, the scale is significantly larger for the V-A compared to the T-C treatment group ($\lambda_{\mathrm{V-A}} = 0.47,\ t - value:\ 6.35$). Given the inverse relationship between the scale and the error variance, these findings imply a smaller error variance for the V-A treatment, suggesting more choice consistency when attributes are presented visually and with affirmative disclosure.

6.3. Sensitivity analysis

Hypotheses one and two concern if information disclosure and presentation format affect average marginal utilities. As a sensitivity analysis, we examine if ANA varies between treatments. Based on the stated ANA, we see that while there are differences between attributes, with fat content, price and LC being the most non-attended, there are only small, and mainly statistically insignificant differences in stated ANA across the treatments for each attribute. More details on the stated ANA are presented in Table A6.

Across treatment groups, the inferred ANA remains relatively consistent, although FTN exhibits a higher inferred ANA in the V-A treatment. Results are reported in Table A7. While FTN demonstrates notable differences in the inferred ANA between treatments, this appears to be an exception and does not provide conclusive evidence of treatment-related differences in ANA overall.

Table 2. Average number of opt-out choices by treatment group

	T-C	T-A	V-C	V-A
Mean	1.31[a, b,c]	0.88[a, d,e]	0.62[b, d]	0.53[c, e]
St. Dev.	2.18	1.76	1.51	1.39

Note: Each respondent made eight choices. Same letters in a row indicate statistically significant differences at 5 per cent level.

While hypotheses one and two concern differences in average mWTP, we also examine the heterogeneity in preferences, as measured by the standard deviations for the attributes in Table 2. Some distinct differences are visible; there is little heterogeneity in the mWTP for RSPCA in the V-A treatment compared to all the other treatments, the same holds in the T-C treatment for PQA and in the T-A treatment for FTN. Results are displayed in Figure A5. Although we observe preference heterogeneity between treatments for certain attributes, no consistent patterns emerge across treatment groups for all attributes. The reasons for these observed patterns remain unclear, and we acknowledge this as an open question for future research.

For the third hypothesis, we investigated differences in choice consistency between treatment groups as measured by the relative size of the error variance. Choice consistency could be related to differences in the cognitive load required to interpret the attributes as well as different degrees of engagement in the tasks. The cognitive load and engagement can also be investigated by the choice behaviour with respect to the opt-out alternative. Each participant made eight choices and the average number of opt-out choices per treatment is presented in Table 2 while the full distribution is presented in Table A8. The opt-out alternative is chosen more often in the complete treatments compared to the affirmative treatments, although the differences are only statistically significant for the textual comparison (T-C versus T-A). Possibly, the complete disclosure results in an information overload, resulting in a higher probability of opting-out. Furthermore, the average number of opt-out choices is higher in the textual treatments compared to the visual treatments, suggesting a higher degree of engagement with visual presentation formats. The total effect of moving from T-C to V-A results in a statistically significantly lower number of opt-out choices, and this difference is large in magnitude.

7. Conclusions and implications

Stated preference methods, including discrete choice experiments (DCEs), enable high internal validity, while the ecological validity can be questioned (Roe and Just, 2009). The use of DCEs has evolved, particularly in the realm of food, towards greater ecological validity. Initially, food DCEs showcased options (food items) as columns in a tabular format, with each attribute described in words. Recently, the presentation style has shifted to formats that better simulate actual buying experiences, displaying the product with images

and the attributes with labels or logos akin to real food items. This development implies that attribute presentation does not only change from textual to visual, but the information disclosure changes from indicating all attribute levels (complete disclosure) to leaving alternatives that do not fulfil the label requirements empty (affirmative disclosure).

Unravelling theory assumes that consumers will fill in the blanks and infer that products with no quality information hold the lowest quality (Ippolito and Mathios, 1990; Grossman, 1981).[4] This study set out to investigate if this holds true in a DCE context. In a between-subject design where attribute presentation format varies between treatments, we find evidence against this assumption; the welfare estimates are lower when the lowest quality level of an attribute is left blank rather than specified. These differences are largest when attributes are presented visually. Importantly, we find that the attribute that is continuous (fat content), and that is thus included in the complete format in both the complete and affirmative treatments, remain unchanged. This implies that by using affirmative disclosure rather than complete disclosure for quality attributes, the marginal utilities are underestimated relative to continuous attributes. Thus, the researcher's choice of how the lowest quality level is presented in a DCE has significant implications on the results.

Given the development in how attributes are presented in food DCE studies, we set to investigate effects on welfare estimates resulting from the movement from textual presentation with complete disclosure towards visually presented and affirmative disclosure. This depends on the effects from moving from textual to visual presentation format and if there is any interaction effects with the information disclosure format. As a first step, we investigated the effects from presenting attributes visually compared to textually. We expected that the increased salience from visual presentation would lead to larger marginal WTP estimates, but while such patterns were observed, these differences were not statistically significant. There is some support for larger marginal WTP when attributes are presented visually (Rihn, Wei and Khachatryan, 2019; Vriens *et al*., 1998), while Katz, Campbell and Liu (2019) find that this holds for some attributes only and DeLong et al. (2021) find the opposite effect. We conclude that the effects from visual compared to textual presentation in a DCE context are not clear and note that this could potentially be attributed to heterogeneity in cognitive style, where some individuals may find visual information more accessible, while others find the opposite (Riding, 2014). In total, we find that the lowering of marginal utilities when moving from complete to affirmative disclosure is not remedied when simultaneously moving from textual to visual presentation. These findings suggest that it remains a concern to compare welfare estimates when presentation format differ in both the disclosure dimension (complete/affirmative) and presentation dimension (textual/visual), since welfare estimates are affected.

4 This prediction of unravelling hold when qualities are vertically differentiated, such that the order of preferences is the same for all consumers, while there can be heterogeneity in the strength.

A related effect from changing both dimensions of attribute presentation concerns choice consistency. We find that the error variance in the choice model, which is inversely related to choice consistency, is lower when attributes are presented visually with affirmative disclosure compared to textual presentation with complete disclosure. This difference is explained by the increased choice consistency from presenting attributes visually rather than textually. Our results suggest that visual presentation of attributes is associated with higher choice consistency compared to textual presentation, a finding that is in line with Lee, Amir and Ariely (2009), and corroborate the findings in a food DCE by Uggeldahl et al. (2016). In contrast, Shr et al. (2019) and Veldwijk et al. (2015) find a lower degree of choice consistency in choices with visual presentation, but we note that these studies investigate landscape attributes and parents preferences regarding vaccines for their children. We speculate if differences in findings relate to the type of product and note that this is an interesting area for future research. We further find that the average number of times the opt-out alternative is chosen is higher when there is more information (complete disclosure), and when the information is presented textually, suggesting that cognitively more demanding processing tasks result in higher rates of opting-out.

We find evidence against the assumption that consumers fill in the blanks when the lowest quality level is left empty. However, it is possible that results to some extent depend on the familiarity with an attribute and its possible levels. Relating the assumptions of unravelling theory to attribute familiarity constitutes an interesting venue for future research. This is particularly important given that it is common practice in food DCEs to include different disclosure and presentation formats in the same study, such that attributes already available on the market are presented using existing labels while new or hypothetical attributes are more likely to be introduced textually with full disclosure to ensure clarity and understanding.

These questions connect to how the task complexity may affect results. Welfare estimates have been found to be affected by the design dimensions of a DCE (Caussade *et al*., 2005; Meyerhoff, Oehlmann and Weller, 2015), where food choice studies show that the number of attributes affect welfare estimates (Caputo, Scarpa and Nayga, 2017; Gao and Schroeder, 2009). Future research should explore if such effects on welfare estimates interact with the degree to which the assumptions of unravelling theory hold.

Although the DCE in this study included binary attributes, the theoretical predictions from unravelling theory extends to multi-level attributes, where all producers except those with the lowest level have incentive to unfold their quality (Ippolito and Mathios, 1990). Our findings are thus of relevance for ongoing policy discussions relating to multi-level nutrition labels and ecological sustainability labels such as Nutri-score and Eco-score (Jürkenbeck, Sanchez-Siles and Siegrist, 2024).

In summary, this study shows that consumers cannot be assumed to infer that products that do not carry information about a quality holds the lowest

quality, thus contradicting the key assumption of unravelling theory in the context of consumer choices in DCEs. Importantly, changes introduced by moving from complete disclosure towards affirmative disclosure remains when simultaneously moving from textual to visual presentation format. These findings can provide guidance on the design of DCE studies. The use of existing or constructed labels and logos increases the ecological validity of the study, and thereby the external validity. However, it is important to note that the purpose of the study should guide the decision on how attributes are presented. If the main purpose is to make as precise market predictions as possible, the affirmative disclosure is the most suitable, since this most closely mimics the situation that will occur in the market. However, if the purpose is to measure informed preferences, for example for policy advice and/or to feed into cost-benefit analysis, then complete disclosure is most suitable as this ensures that respondents are informed on the matter. Providing only affirmative disclosure will downward bias the estimates relative to other attributes that are continuous.

Importantly, based on the results in this study, we caution against mixing formats of disclosure in the same design. Including existing labels in the form of visual and affirmative information for some attributes, while textual and complete information is displayed for other attributes can be expected to bias the results by overestimating the importance of attributes with complete disclosure. This may be particularly worrying if there is a correlation between the familiarity with an attribute and the form of information disclosure.

Finally, our findings are also informative from a policy perspective. The conclusion that complete disclosure of an attribute results in larger willingness to pay estimates suggests that mandatory labelling that ensures complete disclosure will be more effective, a conclusion that resonates with previous studies in the area of carbon labelling (Edenbrandt and Nordström, 2023; Thøgersen *et al*., 2024) and in health labelling (Devaux *et al*., 2024). Moreover, in the design of this study, the lowest quality level in the affirmative treatments were represented by empty space, making the absence of a label more pronounced than in many DCE applications and in a real market situation. This design implies that the observed differences between complete and affirmative information disclosure may understate real-world impacts, and observed effects on welfare estimates are likely even more pronounced in settings where the absence of a label is less emphasized. Thus, the observed differences in this study will potentially translate into even larger differences between voluntary and mandatory labelling schemes in a real market situation.

Supplementary data

Supplementary data is available at *ERAE* online.

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