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ABSTRACT

The psychometric paradigm has dominated the field of empirical work analysing risk perceptions. In this paper, we use an alternative method, Best-Worst Scaling (BWS), to elicit relative risk perceptions concerning potentially unsafe domestic food behaviours. We analyse heterogeneity in those risk perceptions via estimation of latent class models. We identify 6 latent segments of differing risk perception profiles with the probability of membership of those segments differing between experts and the lay public. The BWS method provides a practical approach to assessing relative risks as the choices made by the participants and subsequent analysis have a strong theoretical basis. It does so without the influence of scale bias, the cognitive burden of ranking a large number of items or issues of aggregation of data, often associated with the more commonly used psychometric paradigm. We contend that BWS, in conjunction with latent class modelling, provides a powerful method for eliciting risk rankings and identifying differences in these rankings in the population.

KEYWORDS: *Risk perception; domestic food safety; Best-Worst Scaling; expert-lay differences; psychometric paradigm; heterogeneity*

1. Introduction

Risk perceptions, and the means by which they are elicited, have been studied for many years. The psychometric paradigm has been the dominant method for such elicitation and analysis (see Erdem and Rigby, 2013 for a review of this).

Best-Worst Scaling (BWS) has been proposed as an alternative means to analyse risk perceptions. Erdem and Rigby (2013) used the technique to identify risk preferences and analyse heterogeneity within them. They analysed this heterogeneity using infinite mixture (mixed logit) models in which the risk perceptions are considered to drawn from continuous distributions. In this paper we use the BWS technique but analyse heterogeneity in preferences using finite mixture (latent class models) which allow the identification of discrete segments of the population with differing risk perception profiles. The estimation of the latent classes includes characteristics observed *ex ante* (experts / lay) as well as the BWS choice data. We contend that BWS, in conjunction with latent class modelling, provides a powerful method for eliciting risk rankings and identifying and characterising heterogeneity in risk perceptions.

This paper sets out the Best-Worst Scaling method before setting out the survey and associated model. The results are then presented with a discussion of the heterogeneity explored. In the next section we summarise the use of the psychometric paradigm as the principal method of elicitation of risk perceptions and the challenges of analysing heterogeneity.

1.1. The psychometric paradigm

Individuals evaluate hazards by the use of intuitive judgements with their risk assessments influenced by factors such as the risk posed to them personally, their knowledge of the risk, levels of trust and the newness of the hazard (Boholm 1998). It is for this reason that much analysis of risk perceptions originates in psychological research. The psychometric paradigm, which dominates risk perception literature, conceptualises risk perceptions as multidimensional, with hazards characterised in terms of different dimensions of psychological risk. Erdem and Rigby (2013) summarise the psychometric paradigm, the seminal work undertaken by Fischhoff et al. (1978) and further developments of that research (Sparks and Shepherd 1994; Fife-Schaw and Rowe 1996; Siegrist, Keller, and Kiers 2005; Feng et al. 2010).

Sparks and Shepherd (1994) were the first to apply the psychometric approach of Slovic and Fischhoff to food related hazards whilst Fife-Schaw and Rowe (1996) went on to use this method with the aim of developing additional risk characteristics to define risk dimensions for food related hazards. In addition to hazards and characteristics used previously, they used new ones defined from focus group work, to ensure that they were meaningful to respondents. The results were structured similarly to that obtained previously, however new or little-known hazards (e.g. *Campylobacter*) were found to be positioned in the factor of serious risk, which had not previously been highlighted.

A recurring issue in the use of psychometric approach has been the cognitive load associated with respondents providing multiple criteria Likert scale responses regarding large sets of activities. For example, in the original Fischhoff et al. (1978) study it was acknowledged that the respondents' rating task (of 270 seven-point Likert scales) was arduous, so participants were asked to order and rate the 30 items with regard to its benefit to society or its perceived risk, not both. Similarly, in the Fife-Schaw and Rowe (1996) study they allocated respondents to one of 4 questionnaires so that each respondent had only to provide 110 Likert scale responses in comparison to the more cognitively challenging 270 Likert tasks in Fischhoff et al. (1978) and 575 in Sparks and Shepherd (1994). We return to the issue of cognitive load when introducing the approach used in this study. We now consider another challenge to the psychometric approach: accommodating and analysing heterogeneity in risk perception.

1.2. Heterogeneity in risk perception

A major challenge to the psychometric paradigm is the aggregation of data and analysis of heterogeneity (Bronfman et al. 2007). This aggregation is the averaging of the participant responses prior to analysis, thereby developing an item × characteristic rating matrix. Bronfman et al. (2007). highlight that the variation between participants is masked using aggregate data, whilst at the same time increasing the explanatory power of the psychometric paradigm, perhaps artificially. There have been limited attempts, reported by Bronfman et al. to use the psychometric paradigm without averaging, which appear to further demonstrate that the explanatory power of the psychometric paradigm is reduced with disaggregate data. These methods are in turn criticised for changing the focus from the item differences to that of a participant approach, using a separate participant x characteristic rating matrix per item and therefore changing the research question (Bronfman et al. 2007).

To address this criticism, Bronfman et al. (2007) and Willis and DeKay (2007) combine the standard psychometric paradigm research with individual-difference measures, separating out the level of analysis (aggregate and disaggregate) and focus of analysis (item and participant). Bronfman et al. (2007) included 54 hazards (items) which participants were asked to rate each of them in terms of 19 characteristics. The questionnaire was blocked into 4 versions to ease the cognitive burden for participants so that either 216 or 270 ratings were required depending on the version received. The combined data were then analysed in four ways: aggregate hazard-focused, disaggregate hazard-focused, aggregate participant-focused, disaggregate participant-focused. They found that less variation can be explained with disaggregate data in comparison to aggregate data and that less variation can be explained when differences between participants are the focus of analysis rather than the items (Bronfman et al. 2007; Willis and DeKay 2007).

Siegrist (Siegrist, Keller, and Kiers 2005; Siegrist, Keller, and Kiers 2006) also addresses the difficulty of incorporating heterogeneity in the psychometric study of risk perceptions. He uses a three-way principal component analysis (PCA) to permit the individual differences to be reflected in the final results. Using a three-way PCA allowed assessment of data interactions between items × rating scales × participants, rather than condensing it to two interactions due to aggregation over people. However, this method has been criticised due to the pre-processing of the data. This involved centralising data for each attribute and hazard combination in order to remove 'neutral points' by subtracting from the item rating scale given by a participant, the average rating from each item and characteristic combination. It is as a result of this pre-processing that Bronfman et al. (2007) criticise the elimination of potential sources of variation (attribute and hazard interactions) prior to analysis.

Erdem and Rigby (2013) used BWS to try to address the heterogeneity in the characterisation of risk. The study focussed on a list of food and non-food hazards, in order to elicit levels of control and concern that individuals and groups of people perceived, in relation to the risks presented. In this paper we further this work by the use of latent class analysis to allow the identification of segments of differing risk perceptions, using a sample of experts and lay individuals focussing on a list of food safety behaviours. We incorporate the characteristics of the individual rather than the continuous distributions of mixed logits used by Erden and Rigby (2013). Additionally, we incorporate into the model heterogeneity in choice consistency within response behaviour.

1.3. Expert versus Lay comparisons

A number of studies have sought to compare risk perceptions between groups, such as between the public and experts (Hansen et al. 2003; van Kleef et al. 2006; Webster 2010). Slovic notes that 'lay people sometimes lack certain information about hazards. However, their basic conceptualisation of risk is much richer than that of experts and reflects legitimate concerns that are typically omitted from expert risk assessments' (Slovic 1987, 285). Rowe and Wright (2001) question the validity of lay and expert opinion comparisons. They argued that of the nine studies (Slovic 1985; Kraus, Malmfors, and Slovic 1992; Barke and Jenkins-Smith 1993; Flynn, Slovic, and Mertz 1993; Slovic et al. 1995; McDaniels et al. 1997; Gutteling and Kuttschreuter 1999; Lazo, Kinnell, and Fisher 2000; Wright, Pearman, and Yardley 2000) they evaluated, many were deficient in demonstrating any such gap between lay and experts due to experimental design faults or insufficient allowance for demographic factors that may have affected judgements of risk.

1.4. Food safety behaviours

There is a growing body of research regarding the perception of risk associated with food hazards (Frewer, Shepherd, and Sparks 1994; Fife-Schaw and Rowe 1996; Erdem and Rigby 2013; Kaptan, Fischer, and Frewer 2018). Initial studies in the food sector investigated technological elements of food production such as genetic modification and irradiation, which at the time commanded a high profile in the media. Other research on perceptions of food related risks focussed specifically on risks or case studies arising from food production, such as the incidence of dioxin/PCB contamination (Hammitt 1990; Kennedy et al. 2010; Kaptan, Fischer, and Frewer 2018) and those that consider more general food risks such as the use of irradiation in food preservation (Sparks and Shepherd 1994; Fife-Schaw and Rowe 1996; Erdem and Rigby 2013). Where risk perceptions concerning food poisoning have been considered it has been in very general terms, for example 'food poisoning' being listed as one of many food related risks within a set to be ranked or characterised (Frewer, Shepherd, and Sparks 1994). To date there has been no research into an individual's relative risk perceptions associated with food behaviours that might be routinely undertaken.

In this paper we investigate risk perceptions of domestic food safety behaviours. The focus on behaviours is in contrast to past studies which have featured food poisoning in the abstract or particular pathogens (*Salmonella*, *Listeria* etc). It is motivated by an understanding that the general public tend not to think about specific pathogens but rather conceptualise food risks in terms of behaviours, for example the handling of raw chicken rather than *Campylobacter per se.*

Understanding perceptions of routine behaviours in relation to food may permit better designed and targeted food safety initiatives (Redmond and Griffith 2004; Jacob, Mathiasen, and Powell 2010) to reduce the social and economic disease burden. Whilst it is not clear what proportion of foodborne illness is associated with food prepared in the home (Food Standards Agency 2018), in the food production industry there have been, and continue to be, food safety initiatives to tackle raw materials that pose a risk to consumer food safety (Food Standards Agency 2015). In addition to such initiatives, the food industry is legislated, with monitoring and enforcement programmes in place to reduce food contamination. In contrast, domestic food preparation is unobserved and there is no requirement for food safety training. Food that would be safe if handled, prepared and cooked properly can still present a significant risk to health because of its handling in the domestic kitchen.

In summary, knowledge of risk perceptions that influence domestic food safety is required to target communication in order to reduce food-borne illness. Whilst the psychometric paradigm has been the principal method of analysing risk perception, Frewer et al. report that there is a need to develop more innovative methods of research, including the use of conjoint analysis 'in the assessment of the importance of different interrelated factors within a specific hazard domain' (Frewer et al. 1998, 101). One of the substantive criticisms of the psychometric paradigm research is the aggregation issue previously highlighted. To make a contribution to this debate we test an alternative elicitation method, BWS. One advantage of this method is that there exist a set of models, for the analysis of such choice-based data, which are designed specifically for the analysis of heterogeneity. As we discuss, the BWS approach has some other potential advantages in terms of the cognitive load for respondents and relative to other ranking and rating approaches, such as the use of Likert scales. We now introduce the Best-Worst Scaling technique.

1.5. Best-Worst Scaling

Best-Worst Scaling is a form of conjoint analysis (Finn and Louviere 1992) developed as an extension to Method of Paired Comparison (MPC)(Thurstone 1927). The importance of, or preference for, items such as products, services or risks is often elicited using ranking or rating techniques. Such techniques may include the individual or group ranking of a list of items (Florig et al. 2001; Morgan et al. 2001; Webster 2010), or by asking the participant to assign a rating to each risk item, for example, via Likert scales used in the early stages of the psychometric paradigm, described in section 1.1. In comparison, the use of the BWS elicits importance via repeated choices within subsets of risk items.

Within a BWS study, each participant is shown a number of subsets (a subset of the full list of items). Each subset contains items and participants are asked to select the "best" and "worst" item in the subset. If, within a subset of four, the participant selects "Item 1" as the best and "Item 2" as the worst, through transitive relations, it is known that item 1 is preferred to items 2, 3 and 4, items 2 and 3 are preferred to item 4. The only comparison that cannot be made is between items 2 and 3. A series of subsets of items, determined by an experimental design, are shown in sequence to each respondent. The resulting BW data can be analysed to provide a full, scaled, ranking of the items.

BWS is often used when there is a large set of items for which the researcher seeks to understand their relative importance to respondents. As the participant is not asked to rank the full list, BWS is argued to be less cognitively demanding for the respondent. Further, BWS is argued to have some advantages in comparison to more established forms of ranking and rating, including Likert scale approaches which are typically used in the psychometric studies (Lusk 2009; Cross, Rigby, and Edwards-Jones 2011; Sawtooth 2007), including:

1) The requirement to make best/worst choices forces respondents to discriminate, preventing participants rating many items at equal importance by, for example, using the same response for many/all items on a Likert scale.

2) As there is no scale, scale bias is avoided, such as that from differential interpretations of terms such as "quite likely" versus "very likely", or "agree" versus "strongly agree".

3) Participants are able to judge items at extremes of preference or importance.

To conduct a BWS study one requires items to be ranked, their arrangement in repeated subsets and a criterion for ranking. Thus far the terms 'best' and 'worst' have been used which originate from the more typical use of BWS to assess preferences for product or service attributes. However, the criteria can take many forms. In this study, participants, experts and members of the public, were asked to select the food behaviours they perceived “most likely” and “least likely” to make someone ill with food poisoning. The selection of the items for ranking, study design and recruitment are now described before providing detail of the models estimated on the BWS data and the associated results.

2. Method

2.1. Survey design and recruitment

In this study, fourteen behaviours relating to food safety (Table 1) were chosen for relative risk ranking. As the BWS survey was to be completed by both members of the general public and experts in food safety, it was important that the behaviours used in the BWS exercise were intuitive for all participants. The list of behaviours (Table 1) combined food safety issues that are well known (undercooking of chicken), that have had press coverage (the use of raw eggs), that are not so well known (reheating of rice which potentially has pre-formed *Bacillus* toxin) and issues that could cause concern to individuals but may not be associated with specific food related illness (using a washing-up cloth on the floor). It was intended that the behaviours be unambiguous, leaving little room for varied interpretation, whilst also being examples of routine behaviour.

Repeated subsets comprising four of these fourteen behaviours were provided (figure 1) and participants asked to select the one they perceived “most likely to make someone ill with food poisoning” and the one they perceived “least likely to make someone ill with food poisoning”. Nine subsets of four behaviours were shown to each participant. Research has indicated that a maximum number of 5 items should be presented within a subset, as above this, improvements in estimation have been shown to be small in comparison to the potential participant fatigue or confusion (Sawtooth 2007). The experimental design of the BWS exercise used a programming based algorithm, created using Sawtooth Software’s MaxDiff design module. An orthogonal design was generated, in which each item appeared the same number of times and there was positional balance of the items within the subsets. The design for this study comprised 20 different blocks, each with varying subset combinations. Participants were allocated at random to one block of nine BWS sets.

Demographic information was sought as was information regarding qualifications or experience at work that provided knowledge of food hazards. The survey was completed online with recruitment undertaken via snowball sampling. A recruitment seed email was generated and sent to personal, food industry and academic contacts. Individuals were asked to complete the survey and to pass it on to others. Thirty-five seed emails generated 301 complete responses in four weeks.

2.2. Modelling BWS Data

We analyse BWS risk perception data by estimation of conditional logit (CL) random utility choice models (McFadden 1974), which dominate the empirical analysis of discrete choice data. Typically, CL models concern a person choosing a preferred product or service, that is, choosing the option with the highest utility. In this study, people choose items with highest (lowest) risk, so our exposition of the CL model reflects this. We define the level of risk R_{imt} associated with food behaviour *m* by individual *i* on the *t*th choice occasion, as having a deterministic component η_m and a stochastic element captured by the error term ε:

$$R_{imt} = \eta_m + \varepsilon_{mt} \tag{1}$$

The response variable y_{it} represents the food behaviour chosen by person *i* in set *t*, with the probability that person *i* selects food behaviour *m* as the most risky modelled as a function of the food behaviours which compromise the set. The logit model for individual *i*'s probability of choosing food behaviour *m* as most likely to cause food poisoning is given by:

$$P(y_{it} = m) = \frac{\exp(\eta_m)}{\sum_{m'=1}^{M} \exp(\eta_{m'})} \tag{2}$$

The exposition thus far concerns the choice of food behaviours most likely to cause food poisoning. However, the Best-Worst process also elicits the behaviours considered as least likely to cause food poisoning. The modelling of least likely choices requires a scale factor of -1 to be introduced so that the probability of person *i* choosing food behaviour *m* as least likely to cause food poisoning is given by:

$$P(y_{it} = m) = \frac{\exp(-1 \cdot \eta_m)}{\sum_{m' \in A_{it}} \exp(-1 \cdot \eta_{m'})} \qquad (3)$$

if $m \in A_{it}$ and 0 if $m \notin A_{it}$. Where A_{it} denotes the possible alternatives at replication *t* for person *i.*

In the selection of the best and worst choices (in this case most likely and least likely), we assume that the choices are sequential. As a result, there is one less item to choose from when considering the worst choice and so the probability that the food behaviour already chosen as 'most likely' will be selected as 'least likely' is set to zero.

A particular motivation of the use of the BWS approach to elicit risk perceptions is the investigation in heterogeneity which, as discussed, has been identified as a challenge for the psychometric approach. We explore heterogeneity among the sample via an extension of the CL model in which the presence of latent classes, with differing risk perceptions, is investigated. Incorporating latent classes, *x,* with differing risk perceptions, requires restating (2) as:

$$P(y_{it} = m|x) = \frac{\exp(\eta_m|x)}{\sum_{m'=1}^{M} \exp(\eta_{m'}|x)} \qquad (4)$$

Where the probability that food behaviour *m* is chosen is as a function of the characteristics of the food behaviours that make up set *t,* given the class membership (*x*) of person *i* . The latent class variable takes values $1 \leq x \leq K$, where *K* is the number of latent classes.

Class membership is modelled as a function of personal characteristics using a multinomial logit functional form (Rigby et al. 2011), using a J x 1 vector of individual characteristics C_i and a set of parameters $\phi = \{\phi_x\}_{x=1}^{K}$ to be estimated, where $\phi_x = (\phi_{x0}, \phi_{x1} \dots \phi_{xJ})$ such that:

$$P(x|C_i, \phi) = \frac{\exp(S_x|_{C_i, \phi_x})}{\sum_{x'=1}^{K} \exp(S_{x'}|_{C_i, \phi_{x'}})} \qquad (5)$$

where:

$$S_{x|C_i,\phi_x} = \phi_{x0} + \sum_{j=1}^{J} \phi_{xj} C_{ij} \quad (6)$$

In summary, we model the risk perceptions probabilistically. We do so by estimating random utility models on respondents' BW data. We allow for heterogeneity in risk perceptions via estimation of latent class models. Latent class membership is estimated as a function of individual characteristics. All models were estimated in Latent Gold Choice version 4.5.

3. Results

3.1. Demographics and categorisation

A sample of 301 was recruited which was reduced to 296 after cleaning (the removal of respondents whose BWS choices appeared to be close to random). Of those 296 people, 198 (67%) were female and 98 (33%) male and 31% of households had children under the age of 16. A quarter were between 25 and 34 years old, 30% between 35 and 44 years old, 30% between 45 and 64 years old and 14% over the age of 65.

Responses to open ended questions were used to allocate respondents to one of two groups: "Public", 59.1% - No knowledge and "Expert", 40.9% - Academic knowledge or career in management of food safety.

3.2. Estimates of relative risk perception

The Best Worst Scaling data regarding the fourteen food behaviours was analysed using the models set out in Section 5. Table 2 shows the results of the Conditional Logit model (2) estimated on the entire sample. The coefficients are scaled to have a mean of zero and hence food behaviours with positive coefficients are interpretable as being perceived as above average risk, and those with negative coefficients are perceived as below average risk.

An advantage of the estimation of logistic models is that the coefficients may simply rescaled to ratio-scaled values via the transformation:

$e^{RPi}/(e^{RPi}+a-1)$

where:

R_{Pi}=zero-centred logit score for behaviour i

a=number of items shown per set (in this study, 4)

The resultant rescaled risk perception scores allow interpretation of a behaviour with a value of 2*x* as being perceived as twice as risky as one with a score of *x*, thereby aiding interpretation of the risk rankings (Sawtooth 2007). These rescaled scores are shown in Figure 2.

The two behaviours that were identified as the highest risk were the undercooking of chicken (CHKN=19.30) and cross contamination of salad items with raw chicken (PREP=19.16). At the opposite end of the scale, the least risky behaviours were perceived to be the use of un-pasteurised egg (EGG=2.92), washing raw chicken (WASH=2.71), eating cooked mussels from a restaurant (MUSS=2.40) and defrosting at room temperature (DEFR=2.35). The undercooking of chicken was identified as at least six times more likely to make someone ill than these least risky behaviours.

The results presented thus far concern the sample as a whole. Latent class models of the form in (5) were estimated to explore heterogeneity. In the absence of a test for the number of classes to specify, models with increasing numbers of latent classes were estimated and information criteria used to identify a preferred model (Burton and Rigby 2009). Both the Consistent Akaike Information Criterion (CAIC) and Bayesian Information Criterion (BIC) indicated a 6-class model was preferred. Results from this 6-class model are reported.

A series of personal characteristics were investigated as explanators of class membership (see (6)) and respondents' level of food safety knowledge ('lay'-'expert') was found to significantly affect class membership. Results from the estimation of the 6-class choice model, with 'expert' as a class membership term, are shown in Table 3. Figures 3 and 4 display the ratio-scaled logit scores for this model, the former organised by risk behaviour and the latter by latent class. Of the 6 classes, the expert group are significantly more likely to be members of classes 5 and 6 (1.734, p<0.001 and 1.182, p=0.01) and significantly less likely to be members of classes 1 and 4 (-1.001, p=0.03 and -0.965, p=0.01).

The fact that the data support a 6-class specification indicates that there is very significant heterogeneity within the sample. The significance of the lay-expert term in explaining membership of the 6 classes indicates that this knowledge and training is a significant factor in explaining the heterogeneity. However, the results indicate that the expert-lay dichotomy is only part of the story. We briefly summarise the risk perception profiles of the latent classes below. We report the more notable differences in risk perception, and both differences and similarities in the perceptions of experts and lay public, before discussing their possible causes and implications.

Using the same knife for chopping salad after cutting uncooked chicken (PREP) is assigned the highest risk by all five classes. However, there are significant differences in risk perceptions regarding the other behaviours, evident in Figures 3 and 4 with the latter including the pooled (1-class) estimates also to aid comparison between segments of the sample and the sample average results.

The classes more likely to contain the lay public (Classes 1 and 4) both regarded the relative risk posed by not using antibacterial spray (ANTI) to be of relatively high risk. They also identify similar relative risks posed by cooking chicken from frozen (FROZ), using the washing up cloth on the floor (CLOTH) and eating pink beef burgers (BEEF). However, there are notable differences present in risk perception between the two 'lay classes' concerning eating chicken that has not been cooked properly (CHKN), cross-contamination in the fridge (REFR), BBQ chicken without pre-cooking (BBQ), washing uncooked chicken (WASH), eating unpasteurised egg (EGG) and leaving meat or fish from the freezer to defrost at room temperature (DEFR).

The 'expert classes' (Classes 5 and 6) regard eating chicken that is not cooked properly (CHKN) and eating pink beef burgers (BEEF) as high risk. However, there are notable differences in risk perception between the two 'expert' classes concerning, *inter alia*, the relative risk posed by reheating rice cooled at room temperature (RICE), cooking chicken from frozen (FROZ) and BBQ chicken without pre-cooking (BBQ).

4. Discussion of estimated relative risk perceptions

Classes 1 and 4 (lay) regard not using antibacterial spray (ANTI: 9.69, 9.19) and the use of the washing-up cloth on the floor (CLOTH: 14.44, 7.19) as relatively high risk in comparison to Classes 5 and 6 (ANTI: 1.21, 2.55 ; CLOTH: 1.27, 2.90). These are behaviours that could be regarded as having a prominence in the public consciousness greater than the health threat posed by them, evident by the far lower risk scores assigned to them by the experts.

It is interesting to note that whilst the lay Classes (1 and 4) assess the risk perceptions associated with not using antibacterial spray to be higher than experts at the time of this study, it is expected that significant changes to relative risks would occur due to the Covid-19 pandemic and the emphasis placed on sanitising products (Ciric 2020).

Additional characteristics may be responsible for some of the differences between classes such as a cohort effect. This may be possible in relation to the risk perception of washing of uncooked poultry [WASH]. This is a practice that has become routine to many, who had associated it with good hygiene. The UK Food Standards Agency ran food safety campaigns against this practice on TV and radio in 2007—2009. Such washing was seen as most risky by members of Class 4 (lay class) - It may be the case that they were more influenced by such information campaigns or for them the washing of raw poultry had not become a habit before the public health message changed, perhaps unlike the lay members of Class 1. This may be highlighted by a 2010 (Food Standards Agency 2010) survey which found that 41% of people always wash poultry and red meat. In the same survey, it was found that 30% of 16-24 year olds always washed red meat and poultry in comparison to 47% of people in the age group 75+.

There are some 'expert-lay' differences in relation to the use of unpasteurised egg in an uncooked dessert (EGG). The public advice with regard to the use of raw eggs was that they should be avoided in uncooked dishes and that lightly cooked eggs should not be consumed by vulnerable groups. This was the advice since 1988 when Edwina Currie (UK Government Junior Health Minister at the time) told reporters that 'Most of the egg production in this country, sadly, is now affected with salmonella', angering the egg industry, causing sales of shell eggs to fall significantly and costing Currie her job (BBC 1988). Since 1998, the use of Salmonella vaccination for all British Lion Brand poultry flocks had seen the virtual elimination of Salmonella in British Lion marked eggs, alongside a comprehensive marketing campaign aimed at attempting to improve the reputation of the egg industry. As a result, the UK FSA has softened its advice in recent years (Hughes 2017), although, not all eggs used in the UK are Salmonella free (Little et al. 2006; Wasley, Heal, and Harvey 2019) and some have been found to be the source of a number of outbreaks. One of the classes more associated with members of the public (Class 4) allocated a low risk to the use of unpasteurised egg in comparison to Classes 4 and 5, the 'expert' group. It may be that the latter group were more likely to remember the food scare in the late 1980s and be aware of the issues that remain with the use of uncooked egg, whilst the lay class may not have been so influenced by the media reports of that time.

Changing tastes and responses to messages in the media also provide an interesting context in which to interpret the risk perceptions associated with eating beef burgers pink in the middle (BEEF). Perceptions of the risk from this follow the expert-lay dichotomy with the lay classes allocating it low risk (2.30 and 3.75) whereas Classes 5 and 6 (the expert group) regard it as a much greater risk (13.79 and 8.99). An increasing preference for the eating of beef burgers which are pink in the middle may be linked to the increasing preference (over generations) for rarer cooking of steaks and joints of beef. It is now not uncommon to be asked in some restaurants as to how one would like one's burger cooked (in the same way as one would be asked regarding a steak). This eating of pink ground or minced beef is highlighted by Taylor et al (2012) who found that that 18% of ground beef consumers ate it pink, and Phang and Bruhn (2011) who report 22% of their sample declared a burger cooked when it was at an unsafe temperature. This eating of undercooked food products has been normalised in the mainstream media even though outbreaks have occurred (Jones et al. 2016). The expert Class 5 seems to be less susceptible to the normalisation and cosmopolitanisation of the eating of pink minced beef with this behaviour regarded as being among the 3 most risky behaviours.

While the perception of the hazard posed by rare minced beef differs neatly across the lay-expert divide, this is not the case regarding the reheating of rice that has been cooled at ambient temperature overnight (RICE). This behaviour was included as a hazardous behaviour (because of the likely formation of Bacillus toxins through incorrect cooling of rice) as it was thought that this would be less well known to many. It was viewed as the 3rd highest risk by Class 6 (expert: 15.55). This perception of high risk was not shared with expert members of Class 5 (2.22) or the lay members of classes 1 and 4 (4.22 and 1.33). This result again highlights that the expert-lay distinction is informative in understanding the differences in risk perception, but that those differences are more complex and nuanced than a simple 2 group classification.

5. Conclusions

This research proposes and tests the use of Best-Worst Scaling to elicit relative risk perceptions and to investigate differences in them. This is done for risk perceptions associated with domestic food safety behaviours. The combining of best-worst risk perception data and latent class modelling provides a powerful and flexible method by which to investigate heterogeneity within risk perceptions.

The latent class models estimated highlighted marked differences in relative risk perceptions among the sample regarding the fourteen food behaviours featured. This heterogeneity was shown to be significantly affected by the respondent’s level of knowledge and training regarding food safety. However, the differences in risk perception revealed by the latent class results are far more subtle and nuanced than would be revealed by a comparison between groups identified *ex ante*, in this case between experts and the lay public.

Consumer food preparation behaviour in the kitchen is reliant on knowledge, control and an individual’s personal perception of the risk of food poisoning from behaviours (Redmond and

Griffith 2004). The results reported here, further demonstrate that food safety knowledge plays a significant role in affecting risk perceptions. This method of BWS and Latent Class modelling is capable of providing a detailed understanding of food risk perceptions to target education and communication of food safety messages in order to reduce food-borne illness. To this end, the results from this study demonstrate that simply targeting communication or socialisation of good food safety habits to groups of people is insufficient. This method provides a useful means of segmenting the sample population such that more carefully targeted messages can be made, to better utilise resource.

The food safety behaviours in this study were selected to capture individuals' attitudes with respect to food safety issues, including behaviour that may be habitual, for some people. It was designed so that individuals could relate to their own food handling behaviours rather than ask questions about risk perceptions of food-borne illness. However, comparing the relative risk perceptions of behaviours to a quantifiable measure would be a natural extension to the research. Whilst few data are available to conduct a quantifiable comparison, aligning the focus to food safety behaviours associated with *Campylobacter*, and using appropriate risk factors as a comparison (Neimann et al. 2003; Rodrigues et al. 2001) may prove useful for the aims of the FSA strategy (Food Standards Agency 2015).

As previously stated, risk perception is the way we evaluate hazards using intuitive judgements (Slovic 1987). However, those responsible for food safety in the food industry are trained to use a formal method of risk analysis consisting of three components: risk assessment, risk management and risk communication (FAO/WHO 1996). Whilst the sample population was chosen in order to test the Best-Worst Scaling method, between two groups of people, an interesting extension to the research would be to further classify the experts according to their practical understanding and application of food safety for example as a risk assessor, manager or communicator. Reclassification was undertaken in this study, to identify individuals with knowledge of food safety, which may not be interpreted as a true 'expert' status (Rowe and Wright 2001). However, it is worth noting that this redefined expert group, including a more basic level of food safety knowledge was significant in the final model. This would tend to suggest that many of the food safety behaviours used in this exercise may be based more on a practical level of food safety.

In conclusion, Best-Worst Scaling can be used to elicit relative risk perceptions and can be adopted to investigate perceived risky food safety behaviours. In this study the relative risk perceptions of experts and general public were shown to differ with food safety knowledge influencing latent class membership. This exercise has shown that the BWS method provides a practical approach to assessing relative risks without the influence of scale bias, and without the cognitive burden of ranking a large number of items. The speed with which the data were collected (with no reward for participants), a low drop-out rate and the absence of adverse comments in relation to the exercise are an indication that the BWS tasks were intuitive and not excessively cognitively challenging for the participants.

The choices made by the participants and subsequent analysis have a strong theoretical basis by the estimation of the Conditional Logit model, which is zero-centred and therefore provides an easily interpretable relative risk score based on an odds ratio. The study has also demonstrated differing risk perceptions can be identified, due to the influence of personal characteristics, across a group of people by interrogating the data to reveal latent classes. This provides a strong theoretical basis to analyse risk perceptions, in addition to maintaining the data in a form that permits the detailed investigation of heterogeneity.

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Disclosure Statement

No potential conflict of interest was reported by the authors.

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Tables

Table 1. Food Safety Behaviour Items.

	Behaviours	**Label**
1	Eating chicken that is not cooked through properly.	CHKN
2	Using the same knife for chopping up salad after cutting raw/uncooked chicken.	PREP
3	Cooking raw/uncooked frozen chicken. i.e. not defrosted before cooking.	FROZ
4	Storing raw/uncooked pork (on a plate) on the shelf above cooked ham in the refrigerator.	REFR
5	Eating chicken from a BBQ at a social event (party, sporting event etc) that has not been pre-cooked.	BBQ
6	Using the washing-up cloth to mop up a spillage (such as milk) on the floor.	CLOTH
7	Eating reheated (until piping hot) leftover rice after leaving it out of the fridge to cool overnight.	RICE
8	Chilled foods not being put away in the refrigerator for 4 hours after finishing the shopping.	CHILL
9	Not using antibacterial spray on surfaces after the preparation of raw/uncooked turkey	ANTI
10	Eating a beefburger that is pink in the middle.	BEEF
11	Eating a dessert that contains uncooked/unpasteurised egg such as a tiramisu or chocolate mousse.	EGG
12	Washing a chicken or turkey under the tap before cooking.	WASH
13	Eating cooked mussels in a restaurant.	MUSS
14	Leaving meat or fish from the freezer to defrost at room temperature.	DEFR

Table 2. Conditional Logit model results - Relative risk perceptions of food safety behaviours.

Behaviours	Coefficient	s.e.	z-value
CHKN	2.2564	0.0799	28.2232
PREP	2.2266	0.0791	28.1615
REFR	0.5818	0.0647	8.992
FROZ	0.5545	0.0641	8.6537
BBQ	0.1138	0.0626	1.8183
CLOTH	-0.1574	0.0623	-2.5244
CHILL	-0.2233	0.0622	-3.5907
RICE	-0.2391	0.0632	-3.7835
ANTI	-0.3366	0.0614	-5.481
BEEF	-0.4694	0.0626	-7.496
EGG	-0.9411	0.0617	-15.2515
WASH	-1.0257	0.0636	-16.1348
MUSS	-1.1582	0.0625	-18.5166
DEFR	-1.1823	0.0624	-18.9316

Sample population, N=296.

LL=-5188.38

A description for each behaviour acronym is provided in Table 1.

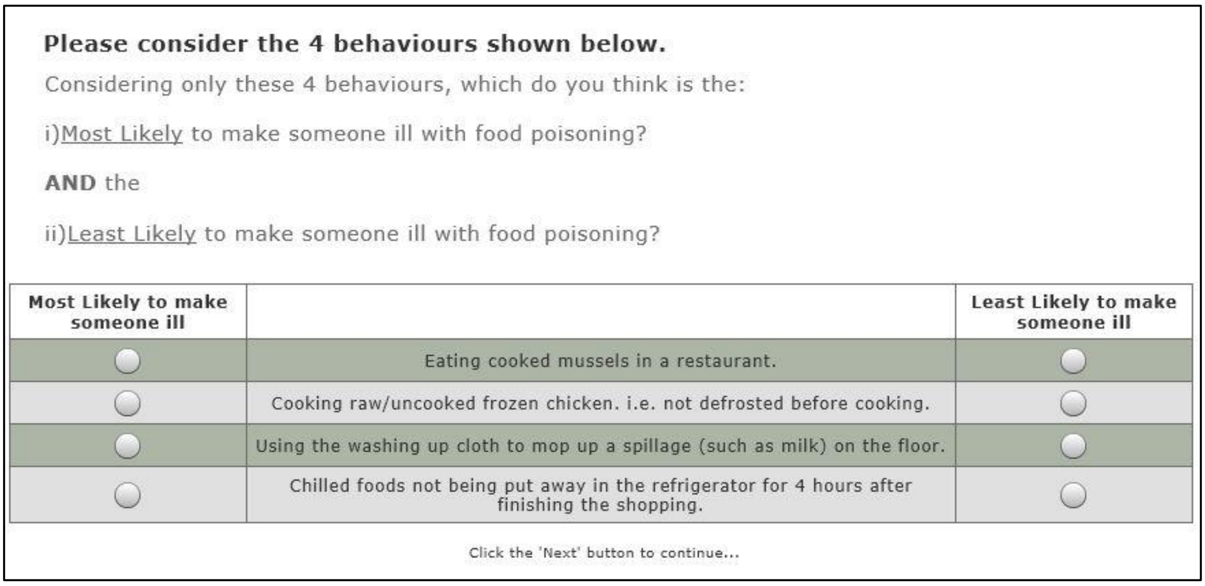
Table 3. 6-class model of risk perceptions of food safety behaviours with expert as a factor.

Behaviour	Class 1		Class 2		Class 3		Class 4		Class 5		Class 6	
	Coeff	s.e.	Coeff	s.e.	Coeff	s.e.	Coeff	s.e.	Coeff	s.e.	Coeff	s.e.
CHKN	1.025	0.227	2.800	0.198	2.863	0.301	2.796	0.263	3.780	0.378	2.411	0.282
PREP	1.454	0.213	2.927	0.204	1.834	0.270	2.903	0.279	4.361	0.442	2.314	0.300
REFR	-0.012	0.253	1.066	0.173	-0.192	0.186	1.437	0.228	0.589	0.252	1.215	0.255
FROZ	0.136	0.254	1.400	0.187	1.253	0.205	0.113	0.243	1.372	0.275	-0.828	0.246
BBQ	-0.621	0.226	0.250	0.169	0.723	0.208	0.374	0.238	0.593	0.265	-1.188	0.247
CLOTH	1.394	0.302	-0.180	0.195	-0.386	0.200	0.292	0.227	-1.727	0.273	-0.866	0.285
CHILL	0.867	0.231	-0.343	0.166	-0.053	0.229	-0.806	0.223	-1.342	0.223	-0.143	0.239
RICE	-0.507	0.248	1.469	0.189	-1.401	0.229	-1.693	0.260	-1.124	0.264	1.766	0.306
ANTI	0.630	0.225	-0.510	0.172	-0.579	0.232	0.687	0.223	-1.782	0.228	-1.010	0.308
BEEF	-1.199	0.247	-1.960	0.177	0.115	0.242	-0.539	0.221	1.537	0.287	0.617	0.289
EGG	-0.552	0.246	-1.948	0.168	-0.237	0.212	-2.086	0.239	-0.950	0.280	-0.298	0.282
WASH	-1.339	0.237	-1.365	0.176	-2.325	0.258	-0.055	0.277	-1.034	0.354	-1.266	0.263
MUSS	-1.179	0.222	-1.956	0.172	-0.167	0.221	-1.650	0.225	-2.157	0.268	-1.420	0.242
DEFR	-0.097	0.228	-1.651	0.160	-1.450	0.198	-1.773	0.206	-2.116	0.219	-1.303	0.268
Model for Classes												
Intercept	0.117	0.232	0.901	0.186	0.419	0.206	0.530	0.207	-1.071	0.418	-0.895	0.376
Expert	-1.001	0.449	-0.449	0.284	-0.530	0.412	-0.965	0.383	1.763	0.446	1.182	0.424

Sample population, N=296.

A description for each behaviour acronym is provided in Table 1.

Figures


Please consider the 4 behaviours shown below.

Considering only these 4 behaviours, which do you think is the:

i)Most Likely to make someone ill with food poisoning?

AND the

ii)Least Likely to make someone ill with food poisoning?

Most Likely to make someone ill		Least Likely to make someone ill
○	Eating cooked mussels in a restaurant.	○
○	Cooking raw/uncooked frozen chicken. i.e. not defrosted before cooking.	○
○	Using the washing up cloth to mop up a spillage (such as milk) on the floor.	○
○	Chilled foods not being put away in the refrigerator for 4 hours after finishing the shopping.	○

Click the 'Next' button to continue...

Fig. 1. Example BWS subset used in this study.

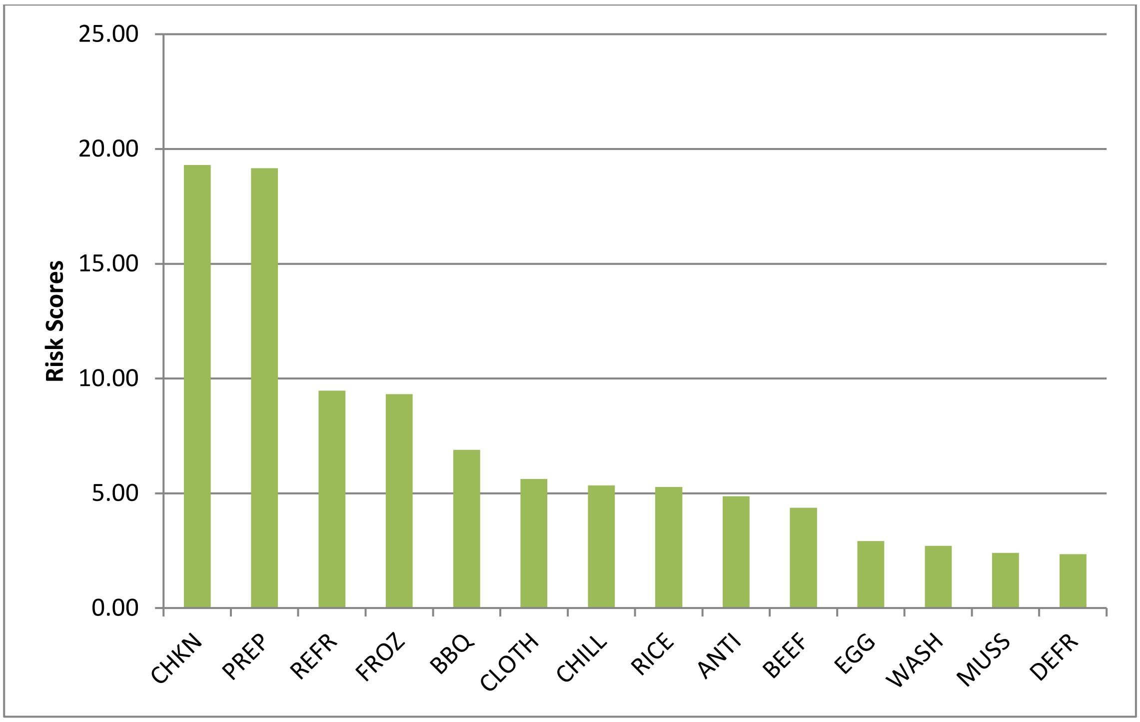


Fig. 2. Ratio-scaled relative risk perceptions of food safety behaviours.

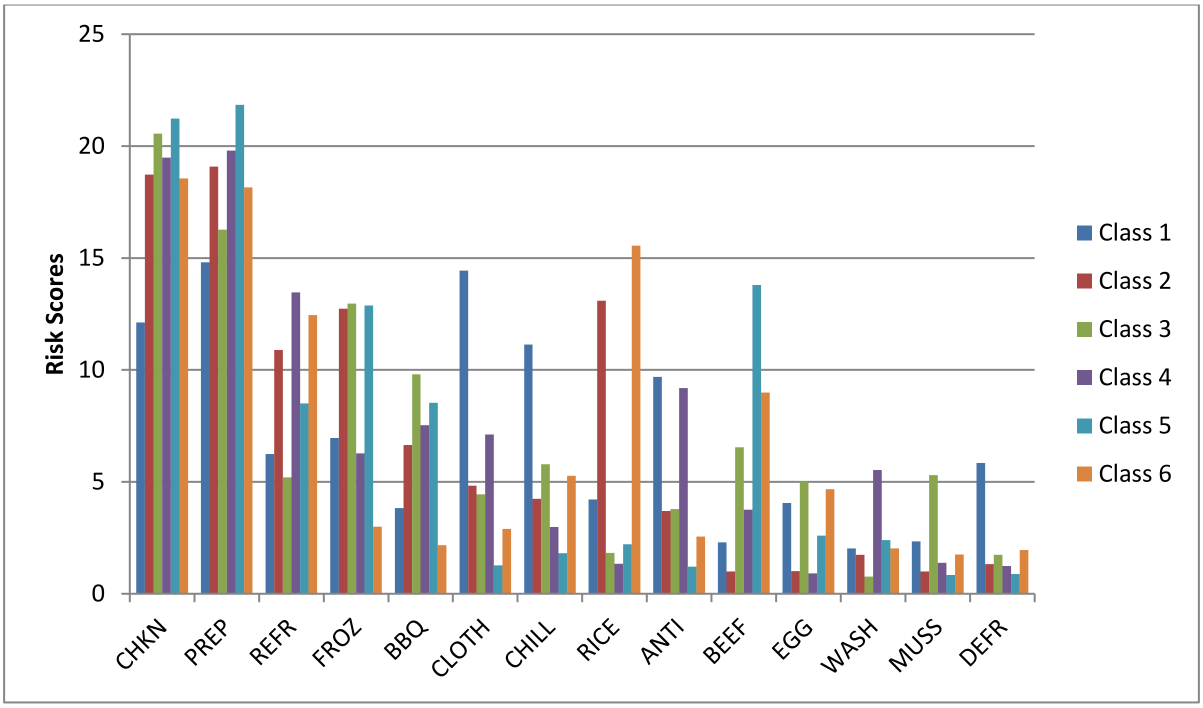


Fig. 3. Ratio-scaled relative risk perceptions, by food behaviour.

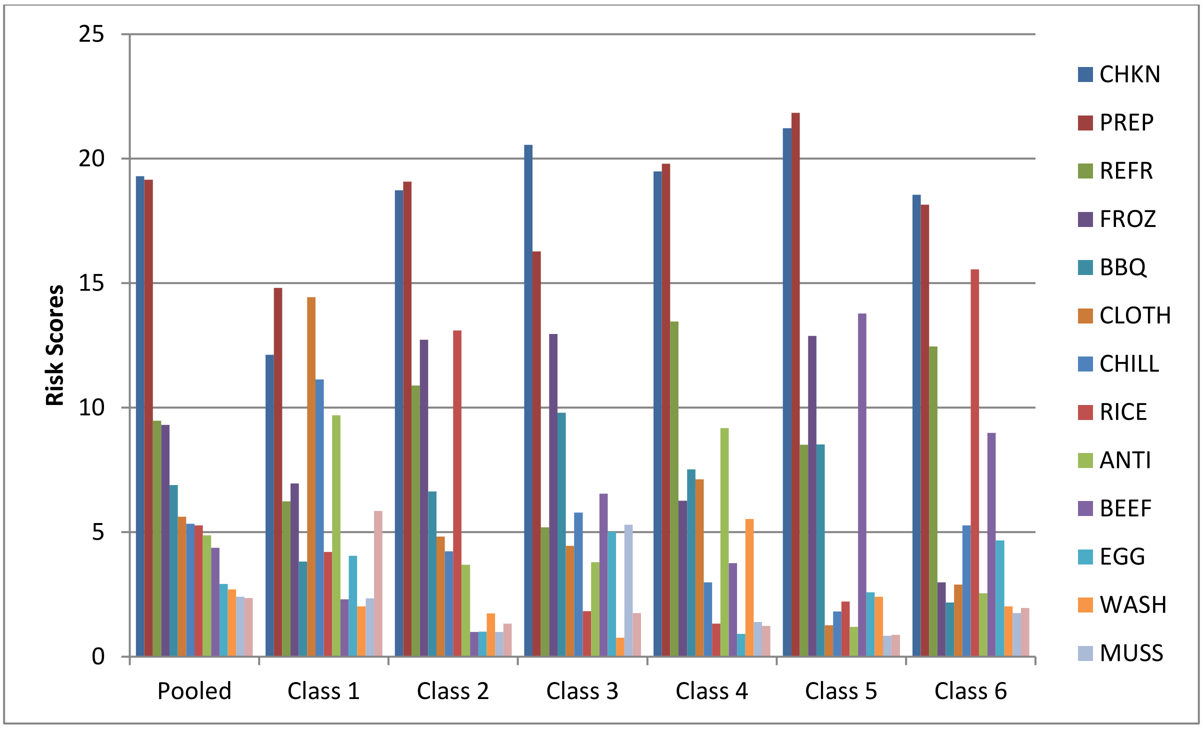


Fig. 4. Ratio-scaled relative risk perceptions of food safety behaviours, by class.

Figure Captions

Fig. 1. Example BWS subset used in this study.

Fig. 2. Ratio-scaled relative risk perceptions of food safety behaviours.

Fig. 3. Ratio-scaled relative risk perceptions, by food behaviour.

Fig. 4. Ratio-scaled relative risk perceptions of food safety behaviours, by class.