INTERPRETIVE SUMMARY

Citizens have diverse preferences for how dairy cows are managed

Jackson

To examine which aspects of cow management and milk are most important to UK citizens, 2,054 study participants were asked to rank 17 attributes in order of importance using choice ‘trade-offs’. Grazing, cow health and welfare, and cow comfort emerged as equal priorities overall, but six underlying groups ranked the choices differently. Each group could be further defined according to 14 characteristics based on demographics, attitudes, experiences and values. The diversity of these groups emphasizes that there is a diversity of preferences for cow management and milk, and citizens perceive cow management attributes in a variety of ways.

Is it just about grazing?

UK citizens have diverse preferences for how dairy cows should be managed

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ABSTRACT

Conflicting views between the dairy industry and its publics about how dairy cows should be managed, together with a rise in the availability of alternatives to dairy foods, challenge future markets for milk producers. Members of the public value animal welfare as well as naturalness and grazing, but neither the relative importance of specific aspects of management nor the diversity of views underlying these headline preferences have been established. To better understand these issues, 2,054 UK citizens recruited through a research panel took part in an online survey. They were asked to rank 17 attributes relating to dairy cow management and milk production through the novel application of 'best worst scaling', a discrete choice methodology that allows a trade-off between items. Hierarchical Bayesian analysis of the results revealed three attributes of equal 'top' importance: (i) access to grazing; (ii) cow health and welfare; and (iii) cow comfort. Alongside this overarching ranking, underlying differences in preferences were established in six approximately equally sized citizen groups within the sample, which were identified through latent class analysis. Each latent class expressed significantly different priorities from the other, and each had different indicative socio-demographic, attitudinal, experiential and value-orientated characteristics, as established through a multinomial logistic model. If the diversity of

preference between the citizen groups found in the sample is reflected within wider populations, there may be opportunities for the dairy industry to improve communication about positive practices, develop new dairy product markets, and/or consider changes to dairy farming systems to better meet different citizens' needs. Furthermore, the defining characteristics and priorities of each group raises the question of whether 'grazing' in particular, but also other attributes presented within the study, are understood in different ways by different sub-groups of citizens.

Key Words: dairy, public opinion, milk, grazing, best worst scaling

INTRODUCTION

Farm animal production methods adopted in the UK and beyond since the second world war have led to more efficient farming which uses less labor and resources, and produces an abundance of safe, affordable and accessible food (Capper et al., 2009; Godfray et al., 2010; FAO, 2017). However, this evolution has raised concerns about an increase in 'factory farming', a term used over 50 years ago (Harrison, 1964) but still employed today to refer to livestock managed intensively with perceived or actual negative outcomes in terms of society, environment or animal welfare (Fraser, 2001; Lusk et al., 2007).

The way in which the global dairy industry manages its cows amid growing economic and environmental sustainability pressures (Peters et al., 2016; Röös et al., 2017), and reconciles these with social sustainability concerns (von Keyserlingk et al., 2013; Britt et al., 2018), is the topic of much debate, not least because of the lack of consensus around what constitutes 'good management'. It has been well-documented that two key stakeholder groups – farmers and publics – often hold conflicting perspectives, particularly on animal welfare. For example, Vanhonacker et al. (2008) reported differences in opinion between citizens and

farmers about whether farm animals were able to engage in natural behavior. The beef and pig farmers questioned in Spooner et al. (2012, 2014a) prioritized biological health and protection from natural hazards for their animals, whereas the citizens in Spooner et al. (2014b) wanted farm animals to have a natural life. A similar disconnect between farmers and agricultural advisors, and "lay citizens", was identified by Cardoso et al. (2018) regarding expectations for dairy farming standards; the farmers and advisors interviewed placed most importance on biological functioning and "lay citizens" instead referred to affective states and naturalness. Survey findings show European citizens have clear expectations that farm animal welfare should be protected (Eurobarometer, 2016), and it was the opinion of Britt et al. (2018) that societal preferences will continue to impact food – including dairy – production as future generations become increasingly displaced from ancestral connections with farming. This phenomenon, coupled with a growing range of alternatives to dairy foods (Graham, 2019), indicates new threats to the economic viability of dairy products.

The case for taking action to address both image and underlying practices of dairy farming as well as the market focus of its products may be evident (Duffy et al., 2006; Ellis et al., 2009), but exactly which aspects are most important to publics, and therefore priorities for the industry to tackle, remains unclear. In many studies, publics express broad and sometimes vague concepts of good farm animal management such as 'animal welfare', and 'naturalness' or natural behaviors (for example: Lusk and Briggeman, 2009; Bazzani et al., 2016). Others have determined support for specific features such as: outdoor access (Lusk et al., 2007; Mulder and Zomer, 2017); reduced stocking density (Liljenstolpe, 2005; Vanhonacker et al., 2008) and improved bedding or flooring (Hall and Sandilands, 2007; Krystallis et al., 2009). Specifically regarding dairy production, Ellis et al. (2009) concluded that the general public aligns good dairy cow welfare most closely with aspects like appropriate feeding, good

stockmanship, cleanliness, and plenty of space or freedom to roam; whereas von Keyserlingk and Weary (2016), referring to Cardoso et al. (2016) and Schuppli et al. (2014), maintained that the public was unanimous in its expectation that cows should have access to pasture. While these studies report their results based on the mean of their participants' responses, others have identified sub-groups with heterogenous preferences regarding, for example, meat production (Meuwissen et al., 2007; de Jonge and van Trijp, 2013), cow-calf separation in dairy cows (Busch et al., 2017), and pasture-based milk production (Weinrich et al., 2014; Kühl et al., 2017). These differing preferences have been explained by a range of factors including: socio-demographics, experiences and knowledge (Kendall et al., 2006; Cornish et al., 2016); belief in an animal mind (Knight and Barnett, 2008); and wider values (Boogaard et al., 2011). However, the relative importance that individuals place on various features of a dairy cow's environment or her management has not previously, to our knowledge, been examined; nor has their heterogeneity of preference, and the characteristics that might affect any differences.

In attempting such an exercise, Likert-type scoring, which is common in eliciting preferences, has the potential to be limited by lack of score differentiation and social desirability bias (Cohen and Neira, 2003; Bertram, 2006). An alternative method is best worst scaling (BWS) which repeatedly presents differently-ordered subsets of the items to participants and asks them to select just the 'best' and 'worst' – or 'most' and 'least' – options, compelling them to trade off items against each other. This method has been found to improve predictability (Adamsen et al., 2013) and has been used in fields ranging from consumer behavior (Jaeger et al., 2008; Mueller and Rungie, 2009) to healthcare (Najafzadeh et al., 2012), food safety (Erdem et al., 2012), food labelling (Ellison et al., 2017) and dairy farmer preferences (Hansson and Lagerkvist, 2016), but not previously for this subject with citizens. Therefore, this study set out to present of a number of different attributes relating to

dairy cow management through the novel application of the BWS method in an online survey of UK citizens. The aim was to obtain a relative ranking of cow management attributes according to their importance in the eyes of citizens, and to determine whether heterogeneity of preference exists as well as an explanation for any differences.

MATERIALS AND METHODS

Data collection and sample

Between 6 and 13 April, 2018, a consumer marketing research company (Made In Surveys https://en.misgroup.io/) with one million panel members globally and 160,000 in the UK, invited its UK members to participate in an online survey on behalf of the University of Nottingham School of Veterinary Medicine and Science. It aimed to recruit socio-demographically diverse citizens aged 16 and over from across the UK to participate, with those completing the survey receiving points towards vouchers as a standard incentive practice used by this marketing research company. While many surveys set age parameters at 18 and over, 16- and 17-year-olds were included due to emerging generational differences in attitudes towards food and animal ethics (Bennett et al., 2017). The sample was balanced by gender, age, geographical region, dietary preference and 'rurality' of area. To secure a representative sample of rural-dwellers with a precision of +/- 2% and confidence level of 95% (385) from an adult population of 35 million in the UK of which less than 20% are likely to be rural (estimated from a rural population of 17% in England (Defra, 2017)), a total sample of 1,418 respondents was required. After adjusting for non-response or non-participation, the sample size was increased to 2,000. The survey was created in Sawtooth Software Lighthouse Studio v9 (Sawtooth Software Inc, 2008), and received ethical approval from the University of Nottingham School of Veterinary Medicine and Science's Research

Ethics Committee. Compliance with General Data Protection Regulation 2016/679 was explained to participants in the survey introduction.

Best Worst Scaling

Best worst scaling (BWS) was the discrete choice methodology used to present a range of cow management attributes to participants. Introduced in the early 1990s (Louviere and Woodworth, 1991; Finn and Louviere, 1992), BWS forces a trade-off by requiring participants to choose the two items that are 'best' and 'worst', or 'most' and 'least', from a subset of (most commonly) four or five items presented to them repeatedly in different combinations. The approach produces both a rank and an interval scaling of the items indicating their relative importance, for both individual participants and for the sample as a whole.

Using Sawtooth Software Lighthouse Studio v9 (Sawtooth Software Inc, 2008), a partially Balanced Incomplete Block Design (BIBD) was created for the BWS exercise according to methods previously described by Sharma (2000). Subsets of the attributes identified for inclusion were presented in a repeated 'tests' which were balanced in (i) factor frequency, (ii) positional frequency and (iii) orthogonality to satisfy optimal design characteristics, following an approach defined by Orme (2009). This means that the attributes were presented an equal number of times in different combinations and orders across a total of 12 tests, with five attributes in each test (Orme, 2005) (for an example of a test, see supplementary tables – Table 5). Given the anticipated range of experiences and knowledge of dairy farming among the participants, it was important to anchor them in an environment to which they could all relate equally. Therefore, a supermarket aisle was selected as the setting, although steps were taken in the framing of the question to eliminate bias due to diet, purchasing habits and concerns over the accuracy of the information provided. Respondents were asked to select the 'most' and 'least' important attributes in each set when asked:

"You are in a grocery shop, walking through the aisle for milk, dairy and plant-based alternatives. More information than usual has been provided about the different types of

cows' milk on display. This has been supplied by a trusted food assurance scheme. Irrespective of whether you are buying any milk or not on this occasion, you have time to spare, so you read the information provided. You will now see a series of questions. Each includes five pieces of information about the cows' milk on display. Which feature is the MOST important and LEAST important TO YOU in each set of five, if price is not an issue? There are 12 questions in total."

Attributes

Thirteen themes related to farm animal or dairy cow management identified from scientific literature and other available reports were judged to be relevant to the research, and were therefore included as attributes in the BWS exercise. These were: i) outdoor access including fresh air, daylight and sun (Vanhonacker et al., 2008; Bergstra et al., 2017); ii) choice of environment and activity (Schuppli et al., 2014; Spooner et al., 2014b); iii) grazing or access to pasture (Spooner et al., 2014b; Cardoso et al., 2018); iv) length of access to grazing, usually in days per year (Kühl et al., 2017; Darwent and Leaver, 2018); v) scale and 'corporatization' of the farm (Lassen et al., 2006; Lusk et al., 2007); vi) individual care and avoidance of commoditization of the animal (Vanhonacker et al., 2010; Cardoso et al., 2018); vii) space allowance or restriction and confinement when inside (Harper and Henson, 2001; Te Velde et al., 2002); viii) nutrition and diet (Ellis et al., 2009; Schuppli et al., 2014); ix) comfort, especially when lying (Vanhonacker et al., 2010; Cardoso et al., 2018); x) health and welfare (Schuppli et al., 2014; Eurobarometer, 2016); xi) mother/offspring separation (Ventura et al., 2013; Hötzel et al., 2017); xii) mechanization and technology (Boogaard et al., 2008; Cardoso et al., 2018); and xiii) behavioral enrichment and ability to investigate surroundings (Vanhonacker et al., 2010; Bergstra et al., 2017). The term 'naturalness' was excluded because it has a more complex range of definitions which are more open to

interpretation than the chosen themes (Nuffield Council on Bioethics, 2015). Other qualitative methods should be used to explore the use of this term.

Some previous studies have indicated a number of participants are more interested in eating quality, or environmental and social impact of food than the welfare of the animals. As a result, four additional 'non-cow' attributes were added to provide alternatives for participants for whom cow management or welfare is of less interest. These were: i) locally-produced milk (Wolf et al., 2011); ii) the taste of milk (Meuwissen and Lans, 2004); iii) a fair price paid to the farmer for milk (Ellis et al., 2009); and iv) the milk's carbon footprint (Vanclay et al., 2011). The price of milk as an end product was deliberately excluded to avoid implying this was a 'willingness to pay' exercise, however this aspect was controlled for in the framing of the question by asking which feature was most and least important "if price is not an issue".

All attributes were phrased in a consistent form in an attempt to mitigate any criticism of terms being presented positivity or negativity, and phrased succinctly to fit within the BWS structure.

TABLE 1 HERE

Values, Attitudes and Experiences

The extent to which respondents believed dairy cows have awareness, can recognize cause and effect, and experience emotions, thoughts or feelings, was explored. This was based on a set of six questions taken from Busch et al. (2017), which was in turn adapted from Hills (1995) (see supplementary tables – Table 6). Other questions included: how rural or urban were the areas in which the respondent had lived; their connection with farming or the dairy industry; whether they had visited farms and, if so, how long ago; experience of keeping pets or animals; dietary preferences; and type of milk or alternative they consumed at typical milk consumption opportunities (Lusk et al., 2007; Ellis et al., 2009). An indication of pre-existing

knowledge of dairy farming was ascertained through three multiple choice questions relating to dairy cows based on Vanhonacker et al. (2007) and Ventura et al. (2016). The respondents were also asked to rate their own knowledge of dairy farming compared with the average UK citizen on a sliding scale of -5 to +5.

Following observations from Boogaard et al. (2011) about the role of values in acceptance of modern day farming practices, an indication of participants' value orientations was obtained using the Schwartz Portrait Value Questionnaire, validated internationally and through its use in the European Social Survey (Davidov et al., 2008). This presents 21 short descriptions of a person's behavior and asks respondents to state for each, on a 6-point Likert-type scale, how like that person they are ranging from "Not like me at all" to "Very much like me". The 21 descriptions relate to 10 different values identified by Schwartz. Centered scores for a respondent's own values are computed by taking the mean scores for the items that index each value then deducting the mean score obtained across all 21 questions (Schwartz, 2003a, 2012).

Statistical Analysis

The BWS responses were analyzed using a hierarchical Bayes framework, a random utility theory approach which is based on the method of paired comparisons (Thurstone, 1927) and commonly used for discrete choice experiments. The underlying hypothesis is that the utility or 'worth' of option 1 over option 2 is indicated by how often option 1 is selected in preference to option 2. The more times option 1 is selected at the expense of option 2, the stronger the preference for option 1 compared with option 2, which results in not just a ranking but also a scale of importance – which Thurstone calls a "distance" between two alternatives. A choice is assumed to have an underlying value, or utility, to respondents. When applying this to a set of options, it is assumed that individuals have an underlying

subjective scale behind their choices and the utility allocated to each item represents where each item is on that scale (Louviere et al., 2013). This can be expressed as:

$$U_{xn} = V_{xn} + \varepsilon_{xn}$$

where: U_{xn} is the unidentified utility that individual *n* associates with choice option or item *x*; V_{xn} is the observable component of utility that can be estimated from behavioral data; and ε_{xn} is the random error component which follows a Gumbel distribution (Louviere et al., 2002).

As described in Shortall et al. (2017), the probability (*P)* that a person will choose item *i* as the most important from a set of *K* items be expressed as:

$$P_i = \frac{e^{Ui}}{\Sigma e^{UK}}$$

where e^{Ui} is the antilog for the utility for item *i* and $e^{UK}$is antilog of the utility scores for each item in the set of *K* items. Conversely, the probability of choosing item *j* as the least important in the set of *K* items can be expressed as:

$$P_j = \frac{e^{-Uj}}{\Sigma e^{-UK}}$$

where e^{-Uj} is the antilog for the negative utility for item j and $e^{-UK}$is antilog of the negative utility scores for each item in the set of *K* items. Finally, the probability that a person will choose items *i* and *j* as most and least important respectively, is the probability that the difference in utility between *i* and *j* is greater than the difference in utility between any other pair in a set of *K* items. This probability (*P*) can be expressed in conditional logit form (*i* is chosen best and *j* is chosen worst) as follows:

$$P_j = \frac{e^{U_i - Uj}}{\Sigma_{m=1}^{K} \Sigma_{l=1}^{K} e^{Um - Ul} - K}$$

where *m* is the most important choice and *l* is the least important choice.

Hierarchical Bayesian Analysis

A hierarchical Bayesian (HB) estimation within the MaxDiff program was used to calculate individual scores under the logit rule (Sawtooth Software Inc, 2008). Using this approach, HB analysis gave an overall ranked and scaled score for each attribute across the whole sample.

Latent Class Analysis

To identify underlying groups which ranked the attributes in a similar way within the overall sample, latent class analysis (LCA) was conducted (Sawtooth Software Inc, 2008). LCA is a measurement model through which individuals can be classified into groupings, or latent classes, based on their pattern of answers from a set of categorical variables – in this case their ranked and scaled attributes from the BWS exercise. This analysis identified underlying groups of participants who expressed preferences similar to each other but different from other groups, and estimated utility scores (with logit scaling) for each group (Orme, 2009). Between two and seven latent class grouping options were considered. While positive but diminishing gains in a Bayesian information criterion (BIC) goodness-of-fit test indicated that five or six latent class groups both presented optimal solutions, six classes gave a better differentiation of preferences between groups. Therefore, a class membership, or group allocation, from the six-class latent class solution was allocated to each respondent based on the maximum probability of their membership of that class.

Multinomial Logistic Modelling

Multinomial logistic modelling (MNL) in Stata 15.1 (StataCorp LLC 1985-2017) was used to build a model in a forward stepwise approach, expressing relative risk ratios (RRR) of an individual belonging to Latent Classes 2, 3, 4, 5 or 6 against that individuals belonging to Latent Class 1. The model was intended to draw out maximum differences between the six latent class groups in terms of related socio-demographic, attitudinal, experiential and value-

orientated characteristics. The moderate nature of Latent Class 1's relationship with most of these characteristics, as opposed to the more extreme relationships exhibited by some of the other classes, provided an informative baseline against which more subtle differences between the groups could emerge. Therefore, when testing for results from the model, using Latent Class 1 rather than any of the other classes as a reference provided most insight to the characteristics of the individuals allocated to the different groups.

The multinomial logistic model can be described as:

$$log\left(\frac{\pi_i^{(s)}}{\pi_i^{(t)}}\right) = \beta_0^{(s)} + \beta_1^{(s)} x_i, \qquad s = 1, \ldots . t-1$$

where the probability of the *i*th respondent being in class s rather than class t is estimated by contrasting each of the response categories with its reference category. In this, the parameter $\beta_1^{(s)}$ is interpreted as the additive effect of a 1-unit increase in x on the log-odds of being in category s rather than category t.

RESULTS

Respondent Characteristics

A total of 2,054 completed survey responses were received over the one-week period. While this was a convenience sample recruited from a panel database, quotas had been set to reflect UK distributions for age, gender, region, dietary preference and the 'rurality' of area in which the participant had lived. The socio-demographic breakdown of respondents is described in Table 2.

TABLE 2 HERE

Ranking the Attributes by Relative Importance

The mean fit statistic for the whole sample was 0.490, indicating that the BWS MaxDiff exercise had been completed to a good level of internal consistency within the sample as a whole. The mean preference scores for each attribute, calculated from the HB analysis of the sample responses to the BWS exercise and scaled for relative importance, are presented in the second column of Table 3 and in Figure 1 in order of ranked importance. There was no significant difference in score between the three attributes ranked top for importance, which were: "*This milk comes from cows that graze outdoors most of the year*" (abbreviated as GrazeM in Table 1); "*This milk comes from farms ranked top in the UK for health & welfare*" (H&W); and: "*This milk comes from farms that prioritize the comfort of their cows above everything*" (Comfort) (P = 0.72 and P = 0.57 respectively). The scores for these three attributes were significantly higher – by almost 20% – than the next nearest attribute: "*This milk guarantees a fair price to the farmer*" (Price).

Attributes relating to the behavioral enrichment of the cow and use of technology *("This milk comes from cows given brushes and toys so they can express their natural curiosity"* (Toys) and: *"This milk comes from farms which use the latest technology and automation"* (Tech) respectively) emerged as the least important attributes. Next lowest – although twice as important as the previous two items according to the scaled scores – was: *"This milk has a lower carbon footprint than other milk and plant-based alternatives"* (Carbon), with attributes relating to size of the farm and the individual level of attention given to the cow (*"This milk comes from small farms where just the family manages the cows"* (Family) and: *"This milk comes from farms where the farmer knows each cow's history and character"* (Individual) respectively) scoring next lowest for importance.

Latent Class Groups

The six groups identified through latent class analysis of the whole sample's individual HB scores all prioritized different attributes (Table 3), with the exception of Latent Class 1

329 and Latent Class 6, which both selected H&W as most important. The groups were relatively
330 evenly distributed within the sample with the numerically largest (Latent Class 4) comprising
331 18.9% of the sample, and the smallest (Latent Class 5), 14.8%.

332 **TABLE 3 HERE**

Multinomial Logistic Regression Model

The multinomial logistic model identified 13 socio-demographic, attitudinal, experiential and value-orientated characteristics that were significant predictors of class membership and hence, potentially, dairy cow management or milk production priorities. These were: age; gender; education; experience of pets or animals; a previous visit to a farm; knowledge of dairy farming; dietary choice; milk consumption choice; the level of belief in 'a dairy cow's mind'; self-rated knowledge of dairy farming; and the three values of achievement, universalism and tradition. Only three of the 10 values in the Schwartz Portrait Value Questionnaire were included due to multicollinearity (Schwartz, 2003a). The RRRs showing the relative likelihood of an individual in Latent Class 2, 3, 4, 5 or 6 having certain characteristics compared with Latent Class 1 are summarized in Table 4.

TABLE 4 HERE

Characterizing the Latent Classes

With each latent class selecting a different attribute as its most important, the classes were named after their most important attribute. The exception was Latent Class 6: as with Latent Class 1, its members identified H&W as their most important attribute, but unlike Latent Class 1, all of the scores awarded to each attribute were much closer together and showed no significant prioritization. For this reason, Latent Class 6 was named the 'No Preference' group and Latent Class 1, the reference class against which the predominant characteristics of the other five classes were estimated, was named the 'Welfare' group.

Because all other classes had a lower RRR than the Welfare group for the value of universalism (i.e. wanting to 'make the world a better place'), members of the Welfare group had the highest probability of including respondents that were orientated towards universalism. Equally they were low in their orientation towards achievement. They were

very likely to have visited a farm at some point, most likely to eat an unrestricted (likely omnivorous) diet, and also the most likely to have had a university education.

By contrast, Latent Class 2, which was labelled the 'Grazing' group after its members' highest-prioritized attribute, included individuals least likely to have lived in rural areas. This group was a third less likely to live in rural areas (RRR 0.7) than the Welfare group and was the most urban/suburban group in the sample. The Grazing group was also the joint-oldest group, particularly with over-45-year-olds who were between 3.4 and 4.9 times more likely to be in the Grazing group than the Welfare group.

Members of Latent Class 3, named the 'Taste' group because of the taste of milk being their most important attribute, were half as likely to believe in a 'dairy cow's mind' (RRR 0.5) as those in the Welfare group. They were 1.8 times more likely to be male, and half as likely to be orientated towards universalism (RRR 0.5). They scored joint highest for dairy knowledge and were around 1.8 times more likely to have got all three multiple choice questions correct, i.e. were more knowledgeable about dairy farming, than those in the Welfare group.

Latent Class 4, which was called the 'Farm Price' group because of its highest-ranked attribute, was similar to the Grazing group in that it generally contained older members; over-45-year-olds were between 2.4 and 5.1 times more likely to be in this group than in the Welfare group. They were also the most likely to be traditional (with higher scores for 'traditionalism – RRR 1.2), and they had the joint-highest level of dairy knowledge alongside the Taste group (RRR 1.8). They were almost a third less likely (RRR 0.7) to have had a university education than the Welfare group, and much less likely (RRR 0.6) to have had a pet or other animal at any point.

Latent Class 5, named the 'Cow Comfort' group after its top-ranked attribute, was characterized by being most likely to have members with a strong belief in a dairy cow's

mind. In fact, out of the whole sample, those having a strong belief in a dairy cow's mind were over 2.5 times more likely to be a member of the Cow Comfort group than the Welfare group. However, they were half as likely to consume cows' milk as those in the Welfare group (RRR 0.5) and two-thirds less likely to have an unrestricted diet (RRR 0.3) – meaning this group contained the highest proportion of vegans and vegetarians. They also had the lowest likelihood of having had a university education (RRR 0.62 compared with the Welfare group, the group with the greatest likelihood of a university education).

As noted earlier, the final class – Latent Class 6 – was named the No Preference group as its members showed very little contrast in preference between the 17 attributes, with the difference in scores between their most and least important attributes just 2.57, compared with the other groups who had score ranges from 14.26 (for the Taste group) to 17.24 (for the Welfare group). Those in the No Preference group were less than half as likely to believe in a dairy cow's mind as the Welfare group (RRR 0.4). They had the lowest experience of pets or animals (RRR 0.4)) but they rated their dairy knowledge the highest of all groups (RRR 1.3), were more than twice as likely to be male than the Welfare group (RRR 2.2), and were more likely than the Welfare group to have never visited a farm (RRR 2.0). As with the Taste group, they were strong on achievement (RRR 1.26), and were almost two thirds less likely to be universally-minded than the Welfare group (RRR 0.4).

DISCUSSION

The novel application of BWS means this is the first study, to our knowledge, to have identified a relative ranking of importance among citizens for specific aspects of dairy cow management and milk production. Furthermore, it is the first to determine heterogeneity of

406 preference in underlying latent classes – or ‘citizen groups’ – and the indicative
407 characteristics of members of these groups.

408 Grazing outdoors most of the year, cow comfort, and health & welfare were all, somewhat
409 unexpectedly, ranked of equal top importance in this study. Dairy cows’ access to grazing is
410 already a well-established priority for publics, expressed both in research (e.g. Ellis et al.,
411 2009; Ventura et al., 2016; von Keyserlingk and Weary, 2016) and campaign group literature
412 (e.g. WSPA, 2010; CIWF, 2011; Darwent and Leaver, 2015), and often cited alongside a
413 belief that it improves cow welfare. This raises questions about the direction of travel of UK
414 dairy farming because despite indications that over 90% of UK dairy farms include grazing as
415 part of their feeding and management regime, this is thought to be decreasing (March et al.
416 2014). While concepts of health and welfare (e.g. Lusk and Briggeman, 2009; Kühl et al.,
417 2019) and animal comfort (Vanhonacker et al., 2008; Cardoso et al., 2018) have also received
418 support from publics in previous research, their equal standing with grazing in this study was
419 unexpected – especially given the strength of preference for grazing and pasture access
420 expressed in aforesaid research. The additional finding that only one of the six underlying
421 citizen groups awarded top importance to grazing means that for this sample of UK citizens
422 at least, preferences for dairy cow management are certainly not all about grazing.

423 Other attributes of relatively high importance included the ability for cows to have outside
424 access even though they live indoors, to choose their own timetable and habitat inside and
425 out, and to keep calves with them for several months. These findings are consistent with
426 previous research: publics in both Spooner et al. (2014b) and Schuppli et al. (2014) supported
427 cows being able to have their feet on pasture or earth, with Schuppli et al. (2014) further
428 establishing that both “lay citizens” and those affiliated with the dairy industry wanted cows
429 to access fresh air and sunshine, and to choose their environment, inside and out. Concerns

around timings for cow-calf separation have also been well-established (Ventura et al., 2013; Busch et al., 2017; Hötzel et al., 2017).

However, attributes identified as less important were revealing too. The low relative importance placed on milk from small family farms did not reflect concerns from publics that larger scale dairy farms negatively impact cow health and welfare, the quality of milk and the naturalness of the animal' circumstances found in Miele (2010) and Cardoso et al. (2016). Nor were concerns evident over the level of personalized care an animal receives (Miele, 2010), with farms where the farmer knows each cow individually also ranked relatively low.

Of the four 'non-cow' attributes explored in this research (i.e. a fair price paid to the farmer, carbon footprint of the milk, taste of the milk, and locally-produced milk), milk that guarantees a fair price to the farmer was most important, and fourth-placed overall. The reasons for its prioritization are not immediately clear. Boogaard et al. (2011) found Dutch consumers would be willing to pay more for milk to support a higher quality product and in Benard and de Cock Buning (2013), it was acknowledged by both farmers and citizens that the ability to provide better welfare was linked to the income farmers received. In our study, three of the underlying citizen groups identified through LCA (the Welfare, Taste and Price groups) placed a high relative importance on a fair price to farmers. The priorities and characteristics associated with these groups may imply motivations are linked to a notion of fairness for not only for the cows but also for the farmer working with the cows, or to enabling the farmer to produce better milk, or to supporting rural communities and traditional ideals. It would be helpful to use further methods to unpack the notion of fairness in particular. An alternative explanation is that the price paid to farmers was at the forefront of participants' minds because of publicity surrounding farm-gate milk price in the media, although this issue peaked in prominence two years before the survey took place (News, 2015).

455 The scaled rankings identified for each of the underlying citizen groups provide further
456 insight to importance of the different attributes in relation to each other, and the differences in
457 priorities. For example, the Welfare group rated health and welfare almost twice as important
458 as it rated grazing outdoors most of the year, but the Grazing group rated grazing most of the
459 year over three times more important than health and welfare. These quantitative differences
460 in preference between the groups illustrate that the top priorities for the whole sample were
461 formed not from homogenous views, but from a combination of strong and differing
462 preferences expressed by individuals within the underlying citizen groups.

463 The characteristics found through the multinomial model to be the strongest indicators of
464 membership of a particular citizen group were coherent with previous research and with each
465 group's priorities. Belief in an animal mind, as described by Knight and Barnett (2008) and
466 Busch et al. (2017), was strongly exhibited in the Cow Comfort group, which prioritized
467 attributes that could be connected with a cow's behavioral wellbeing such as choice about her
468 environment or staying with her calf. As suggested by Boogaard et al. (2011), personal values
469 were also significant. For example, the Welfare, Grazing and Cow Comfort groups which
470 prioritized cow-related attributes scored highest for universalism, indicating an interest in
471 fairness and making the world a better place for others (including animals); the Taste and No
472 Preference groups, which did not prioritize cow attributes, scored highest for achievement
473 which suggests more self-interest. The socio-demographic and experiential characteristics
474 identified as significant indicators were consistent with reviews conducted by Kendall et al.
475 (2006) and Cornish et al. (2016), namely that age, gender, education, dietary and milk
476 consumption choices, pet ownership, experience or knowledge of farming, and rurality are all
477 linked to attitudes towards animal welfare.

478 While use of BWS was successful in establishing ranked preferences and identifying the
479 underlying heterogeneity in the sample, the necessary brevity of the attribute descriptions

gives rise to speculation about how participants interpreted and understood each attribute, or how the presentation and wording of the attribute influenced prioritization or trade-offs. Some attributes could have been assumed as 'givens' – already delivered under a farmer's duty of care to his or her animals, hence were traded off in favor of attributes seen as currently unmet needs. Miele (2010) observed that for the vast majority of focus group participants in her study, issues such as hunger and thirst were considered very important but were also problems that "should not exist anymore in a 'civilized' Europe". Visits to farms reported in Boogaard et al. (2008) and Ventura et al. (2016) satisfied some concerns of the participants but raised other concerns in areas they had previously assumed to be satisfactory. Hence, in this study, it is possible that participants inadvertently downgraded attributes that nonetheless hold great importance for them. Furthermore, some attributes could have been seen as proxies or enablers of others. For example, some may believe grazing delivers improved health and welfare, or better cow comfort or a more suitable diet, hence prioritizing grazing will prioritize some associated attributes by default. Despite this, the identification of latent classes linking different rankings with specific characteristics such as dairy knowledge, rural experiences and values, gives some indication of the possible frames through which these attributes may have been interpreted. More research to clarify the reasons behind the choices made by different groups of participants would be worthwhile.

Given evidence of a disconnect between the dairy industry and other stakeholders priorities (Vanhonacker et al., 2008; Cardoso et al., 2018), this research suggests a number of priorities the industry could seek to address. These could include: better communication of how the industry is meeting cows' needs and public expectations around these aspects (e.g. delivering cow comfort, or cow health and welfare); targeted product marketing based on key attributes of importance (e.g. grazing or a fair price for farmers); or adaption of current farming practices to address aspects of most concern (e.g. outdoor access for cows which

505 otherwise remain indoors). However, the questions remain as to what meanings people have
506 constructed around these attributes and what practice and process interventions on-farm
507 would deliver them, subjects we intend to investigate in a following study. As a minimum,
508 the benefits of this study come from improved understanding and better "anticipating societal
509 debates" (Vanhonacker et al., 2008).

510 Several limitations to this study are acknowledged. The data were collected online through
511 a marketing research panel whose members are 'paid by survey', irrespective of how
512 accurately they complete the exercise. This raised the potential for bias in the survey sample
513 towards people who are more disposed to take part in online research panels, but also for
514 inaccuracy if there is no incentive to complete the survey with care. While the sample was
515 broadly representative of the population with a few minor exceptions, there was low overall
516 representation of ethnic groups. Media or marketing could have had impacts beyond those
517 already discussed. However, stories over the past decade almost exclusively focus on whether
518 dairy cows graze (for example Webster, 2015 and Blythman, 2017) and claims on milk
519 packaging relate mainly to grazing (Darwent and Leaver, 2015; Rodionova, 2017). Hence
520 these external influences could explain heightened support for grazing, and not for the equal
521 priority placed on health and welfare and cow comfort, or the different priorities of the five
522 other citizen groups. The use of UK citizens in the study could affect its relevance elsewhere.
523 Yet the attitudes, concerns and preferences and the demographic groups expressing them are
524 broadly consistent with previous research from a number of other countries, and Schwartz's
525 values are validated across cultures (Spini, 2003; Davidov et al., 2008); this suggests
526 countries with similarly developed dairy sectors and consumer affluence may find
527 comparable heterogeneity of preference within their populations. Finally, while BWS was
528 novel to this area and pivotal in obtaining the scaled rankings central to our results, it can
529 only indicate relative importance, hence the top and bottom-ranked attributes were only most

and least important relative to the 17 attributes offered, and their wider importance or unimportance in relation to other attributes cannot be construed from the results. As previously discussed, the necessarily concise attribute descriptions within the BWS exercise were a key limitation of using a quantitative approach, thus further studies should attempt to more fully understand, through qualitative methods, what participants may have believed when they selected the attributes they did as most or least important.

CONCLUSIONS

The novel methodologies used in this study to examine citizens' rankings of importance for different aspects of milk and dairy cow management have revealed a wide range of preferences and a clear order of priority. Six underlying citizen groups within the sample, which were approximately equally sized, each expressed significantly different priorities from each other and had different indicative socio-demographic, attitudinal, experiential and value-orientated characteristics. If the diversity of preference and characteristics in this sample is representative of wider populations, it suggests the dairy industry has an opportunity to address the current disconnect between dairy farming and its different publics through improved communication, marketing, or changes to farming systems. Building on the findings of this study through qualitative research should reveal more about the understandings different citizens have of the features or benefits inherent in some of the attributes presented.

Acknowledgements

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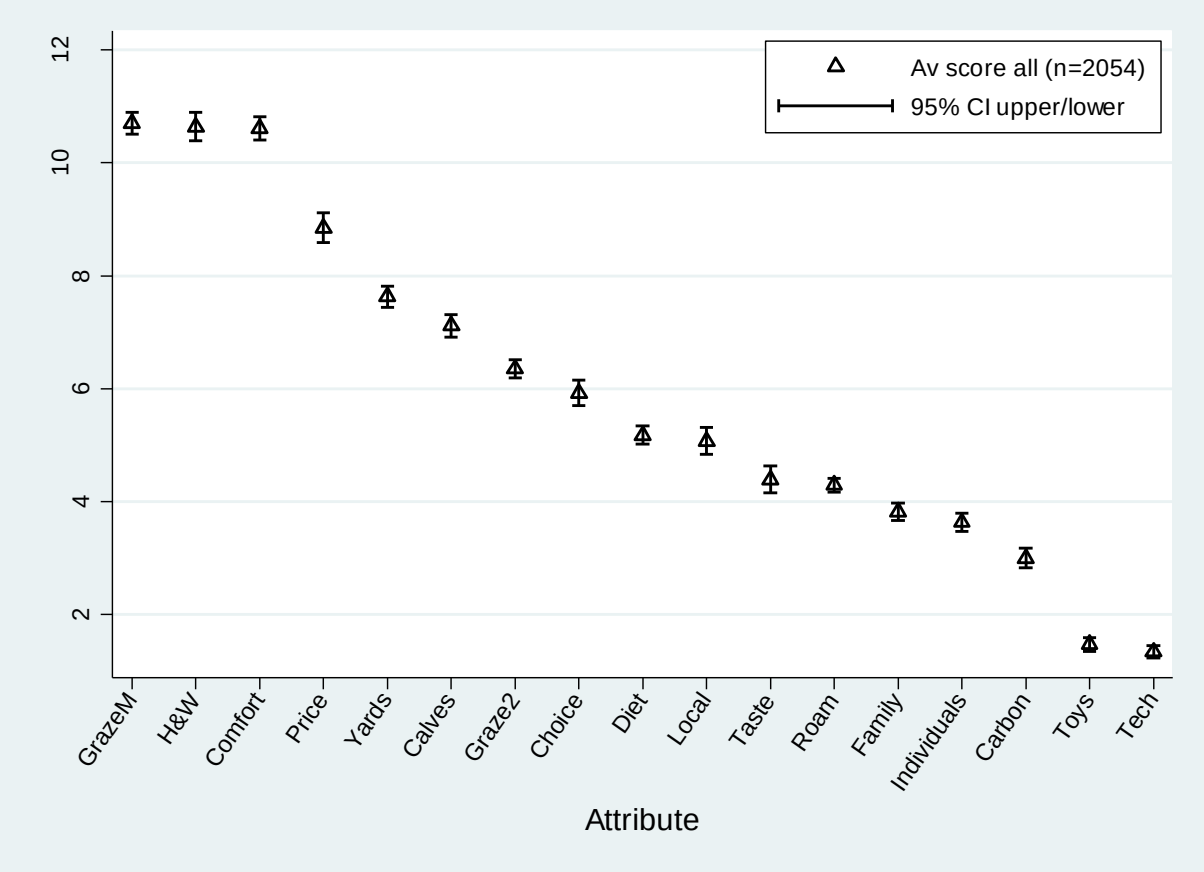
FIGURES



Jackson
Figure 1.

Caption for Figure 1.

The 17 attributes in order of declining ranked importance after hierarchical Bayesian analysis (n=2,054)

TABLES

Table 1. The 17 attributes tested in the best worst scaling (BWS) exercise, which were presented in subsets of five within 12 differently-ordered combinations

"This milk…"	Abbrev. attribute
is from cows managed indoors that can walk into open outdoor yards at any time	Yards
is from cows that choose their own timetable and habitat, inside and out	Choice
comes from cows that graze outdoors most of the year[a]	GrazeM
comes from cows that graze outdoors for at least a couple of months each year[a]	Graze2
comes from small farms where just the family manages the cows	Family
is from farms where the farmer knows each cow's individual history and character	Individual
comes from farms where cows roam freely when indoors	Roam
is from cows fed a diet designed to meet their individual nutritional needs	Diet
is from farms that prioritize the comfort of their cows above everything	Comfort
is from farms ranked top in the UK for health & welfare	H&W
comes from cows that keep their calves beside them for several months	Calves
is from farms which use the latest technology and automation	Tech
is from cows given brushes and toys so they can express their natural curiosity	Toys
comes from farms local to your area	Local
tastes better than other cows' milk	Taste
guarantees a fair price to the farmer	Price
has a lower carbon footprint than other milk and plant-based alternatives	Carbon

[a] these attributes were prohibited from appearing together

Table 2. Socio-demographic breakdown of the respondents completing the online survey (n=2,054)

Variable	Sample results
Age	Mean 45.94 years, range 16-86 years Percentage in each age category – 16-24: 10.91% (ONS[a]: 13.47%); 25-34: 21.03% (16.74%); 35-44: 16.71% (15.58%); 45-54: 18.62% (17.27%); 55-64: 14.30% (15.54%); 65-74: 14.69% (12.30%); 75+: 3.73% (10.10%)
Gender	Male 43%, Female 56%, Other <1%, Prefer not to say <1%
Region	North West 13%, North East/Yorkshire 13%, East Midlands 9%, West Midlands 11%, East/East Anglia 9%, South East/London 23%, South West 9%, Wales 5%, Scotland 7%, N Ireland 2%
Children	Responsibility for children – No 41%, Yes now 30%, Yes used to 29%, Other <1%
Area	Mainly lived in – Urban 38%, Suburban 34%, Rural 16%, Mix of places but not rural 2%, Mix of places including rural 9%, Other <1%
Income	Household take-home annually – <£20k 29%, £20-40k 35%, £40-£60k 16%, £60-£100k 8%, >£100k 2%, Prefer not to say 10%
Education	Highest achieved – School 28%, College diploma 16%, Degree 32%, Postgraduate 13%, Vocational/skilled 9%, Other 1%, Prefer not to say 1%
Ethnicity	White 90%, Mixed 2%, Asian 5%, Black 2%, Other <1%, Prefer not to say 1%

[a] ONS (2017)

Table 3. Overall ranking and hierarchical Bayesian (HB) scores for the 17 attributes alongside individual HB scores for each underlying latent class

Overall Ranking	HB[a]	Abbrev. attribute	Class 1 (Welfare)[c]	Class 2 (Grazing)[c]	Class 3 (Taste)[c]	Class 4 (Farm Price)[c]	Class 5 (Cow Comfort)[c]	Class 6 (No Preference)[c]
	Class size (% of sample)		18.3%	15.6%	15.2%	18.9%	14.8%	17.2%
1	10.70	GrazeM	9.56	**16.83**[b]	10.44	10.59	10.45	6.18
2	10.64	H&W	**17.76**[b]	5.28	13.43	9.30	9.91	**7.34**[b]
3	10.61	Comfort	15.02	11.12	7.24	8.44	**15.97**[b]	6.60
4	8.85	Price	12.43	5.00	11.98	**15.29**[b]	2.05	5.71
5	7.63	Yards	7.40	11.48	5.58	4.91	10.16	6.49
6	7.12	Calves	7.53	8.85	3.73	5.66	11.02	5.59
7	6.35	Graze2	5.71	10.63	6.39	5.36	4.92	5.72
8	5.92	Choice	5.67	7.94	1.76	2.43	12.43	5.77
9	5.18	Diet	5.78	4.11	6.60	3.09	5.24	6.35
10	5.07	Local	1.60	1.93	4.08	13.63	0.93	5.34
11	4.39	Taste	1.05	2.97	**14.67**[b]	2.07	0.66	5.69
12	4.29	Roam	3.64	5.71	3.90	3.14	4.99	6.24
13	3.82	Family	1.91	3.05	2.56	8.21	2.47	5.07
14	3.63	Individual	1.85	2.76	1.76	4.93	3.75	5.63
15	2.99	Carbon	2.19	1.25	3.94	1.80	1.28	5.85
16	1.47	Toys	0.52	0.41	0.41	0.44	3.50	4.77
17	1.34	Tech	0.39	0.69	1.53	0.72	0.29	5.65

[a]Hierarchical Bayesian score indicating scaled ranking by importance
[b]Most important attribute in each class is identified in **bold**
[c]Each class name is in (brackets) in the column heading

581 **Table 4. Relative Risk Ratios (RRR) of belonging to Class 2, 3, 4, 5 or 6, against belonging to Class 1, for variables included in the**
582 **multinomial logistic model**

	Class 2: Grazing		Class 3: Taste		Class 4: Farm Price		Class 5: Cow Comfort		Class 6: No Preference	
	RRR	95% C.I.	RRR	95% C.I.	RRR	95% C.I.	RRR	95% C.I.	RRR	95% C.I.
Age *(compared with being 16-24 in Class 1)*										
25-34	1.28	0.62-2.62	1.15	0.63-2.08	1.55	0.81-2.95	0.64	0.35-1.16	1.16	0.66-2.05
35-44	1.94	0.94-4.00	1.06	0.56-2.00	1.51	0.77-2.96	1.07	0.58-1.94	1.04	0.56-1.91
45-54	3.40***	1.67-6.91	1.29	0.68-2.47	2.42**	1.25-4.71	1.28	0.70-2.33	0.82	0.43-1.56
55-64	3.60***	1.73-7.48	1.38	0.70-2.71	2.77**	1.41-5.45	0.69	0.35-1.35	0.58	0.28-1.19
65-74	4.87***	2.34-10.16	1.90	0.97-3.74	3.11***	1.56-6.17	0.67	0.33-1.36	0.26**	0.11-0.63
75+	4.70**	1.62-13.66	2.79*	1.01-7.68	5.12***	1.95-13.48	0.88	0.26-3.00	0.51	0.14-1.90
Belief in a dairy cow's mind	0.94	0.74-1.20	0.49***	0.38-0.64	0.72**	0.57-0.91	2.57***	1.99-3.32	0.45***	0.34-0.58
Dairy cow knowledge *(reference: fewer than 3/3 correct answers)*	1.05	0.65-1.69	1.85*	1.15-2.98	1.84**	1.20-2.83	1.05	0.62-1.77	0.86	0.48-1.55
Rurality *(reference: has not lived in rural areas)*	0.66*	0.45-0.96	0.73	0.49-1.08	1.38	0.98-1.94	0.89	0.60-1.31	0.73	0.47-1.13
Type of milk consumed *(reference: does not mainly drink cows' milk)*	1.41	0.68-2.92	1.19	0.60-2.34	1.76	0.83-3.71	0.46**	0.26-0.82	0.67	0.36-1.24
Dietary preference *(reference: restricted diet, e.g vegetarian)*	0.69	0.41-1.14	0.77	0.44-1.34	0.82	0.49-1.37	0.33***	0.21-0.52	0.62	0.36-1.07
Education *(reference: not university-educated)*	0.76	0.54-1.06	0.90	0.65-1.27	0.70*	0.51-0.97	0.62**	0.44-0.89	0.75	0.53-1.07
Experience with animals *(reference: has no experience)*	0.70	0.42-1.15	0.50**	0.31-0.80	0.60*	0.37-0.96	1.10	0.62-1.94	0.38***	0.24-0.62
Self-rated dairy cow knowledge	1.06	0.98-1.14	0.99	0.92-1.07	1.08*	1.00-1.16	1.02	0.94-1.10	1.30***	1.20-1.41
Gender *(reference: female)*	1.30	0.94-1.81	1.77***	1.27-2.49	1.07	0.78-1.47	0.84	0.59-1.21	2.21***	1.55-3.16
Farm visit experience *(reference: has visited a farm in the past)*	1.13	0.77-1.66	1.15	0.78-1.69	1.04	0.71-1.52	1.25	0.83-1.89	1.98***	1.33-2.94
Achievement	1.12	0.91-1.37	1.28*	1.05-1.58	1.01	0.84-1.23	1.11	0.90-1.37	1.26*	1.01-1.56
Tradition	1.16	0.95-1.40	1.04	0.85-1.27	1.23*	1.02-1.48	1.07	0.88-1.30	0.93	0.76-1.15
Universalism	0.65***	0.51-0.84	0.52***	0.40-0.67	0.62***	0.49-0.79	0.88	0.68-1.14	0.36***	0.28-0.48

583 The reference class used was Class 1: Welfare; all RRR figures are expressed relative to Class 1
584 Key: *P<0.05, **P<0.01, ***P<0.001; RRR=Relative Risk Ratio; 95% C.I. = 95% confidence interval

SUPPLEMENTARY TABLES

Table 5. An example 'test' in the best worst scaling (BWS) exercise, showing a subsection of five randomly-presented attributes

Most Important	Least Important	**"This milk..."**
☐	☐	comes from cows that keep their calves beside them for several months
☐	☐	comes from farms where cows roam freely when indoors
☐	☐	has a lower carbon footprint than other milk and plant-based alternatives
☐	☐	comes from farms local to your area
☐	☐	is from farms which use the latest technology and automation

589 **Table 6. Socio-demographic, attitudinal, experiential and value-orientated variables included in the online survey which identified**
590 **common characteristics of respondents (n=2,054) with different preferences for dairy cow management and milk**

Variable	Categories
Source of food	Supermarket, Online, Convenience store, Farm shop, Deli or independent, Homegrown, Other
Times/week you shop	Most days, 2-3 times a week, Once a week, Less than once a week
Type of milk or alternative consumed	Cows' milk, Other animals' milk, Plant-based alternatives, None
Frequency of consumption	Several times a day, Once daily, Every few days, Once a week or less
Last story heard/seen about dairy farming	*Free text*
Age	*In years*
Gender	Male, Female, Other, Prefer not to say
Region you have mostly lived in	N. Ireland, Scotland, NE England, NW England, E. Midlands, W. Midlands, E. Anglia, SE England, SW England, Wales, Other
Long term responsibility for children	No, Yes now, Yes used to, Other
How many children in each bracket	Less than 2, 2-4 years, 5-8 years, 9-11 years, 12-15 years, 16 plus
Type of area lived most of your life	Mainly: towns or cities, Suburban, Rural, Mix not rural, Mix including rural, Other
Closest links to or experience of farming or dairy	No links, Occasionally visited farm or dairy but no other links, Friends or non-immediate family have farmed, Worked in farming, with farming or in the dairy industry, Immediate family or I have farmed
Last time visited a working farm	Never, More than 5 years ago, Within the last five years, Within the last year, Within the last month
Experience keeping animals	Own/have care of pet/animal now, Owned/had regular pet/animal in past but not now, Never had responsibility for animal, Other
Which best describes your diet	Omnivore (unrestricted diet), Pescetarian, Flexitarian, Vegetarian, Vegan, Dairy-free, Other
Take-home income for household	<£20,000 annually, £20,000-£40,000, £40,000-£60,000, £60,000-£100,000, >£100,000 annually, Prefer not to say
Highest level of education	School, College Diploma, College/University Degree, Postgraduate, Vocational/skills-based, Other, Prefer not to say
Ethnicity	White, Mixed or multiple ethnic groups, Asian/Asian British, Black, African, Caribbean/black British, Other, Prefer not to say
Level of dairy cow knowledge	Three multiple choice questions presented: a) Number of liters a cow produces annually: 7.5 liters, 75 liters, 750 liters, 7,500 liters, Not sure b) Cows most frequently give birth to: A single calf, Twins, Triplets, Quadruplets, Not sure c) Biggest part of an adult dairy cow's diet in the UK: Milk, Grass or similar, Grains, Soya, Not sure
Self-rated dairy knowledge	Sliding integer scale from -5 to +5 including 0, with -5=no knowledge compared with the average UK citizen, 0=average, 5=very knowledgeable compared with the average UK citizen
Belief in a dairy cow's mind	To what extent do you agree with the following six statements? Scores for a) b) and c): Definitely disagree (1 point), Probably disagree (2), Don't know (3), Possibly (4), Probably agree (5), Definitely agree (6). Statements d) e) and f) are reverse-scored. a) Cows are conscious and aware of what is happening to them b) Cows are able to think to some extent to solve problems and make decisions about what to do c) Cow are capable of experiencing a range of feelings and emotions d) Cows have a limited mental ability to see cause and effect of an action e) Cows experience emotions less intensely than humans f) Cows mechanically respond to instinctive urges without awareness of what they are doing
Values	Methodology as described in Schwartz (2003a, 2003b) . 21 'portrait' statements scored as follows then computed: Not like me at all (1), Not like me (2), A little like me (3), Somewhat like me (4), Like me (5), Very like me (6)

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