Exploring Emotional Dimensions of Food Waste Perception

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Abstract Approximately one third of the food produced globally is lost (14%) or wasted (17%) (FAO, 2019; UNEP, 2021). This phenomenon deserves full attention from governmental institutions and the academic community. The European Commission has just proposed to include food waste reduction targets for 2030 in its Waste Framework Directive. As two main areas for reduction are retail and household food waste, citizen panel discussions have already begun to understand their views on the topic. Given these concerns, in this paper we consider a qualitative reasoning model using hesitancy to explore people's emotions towards the environment with a specific focus on food waste. We collected data from 188 participants in an in-person taste experiment. We analyze consumers' preference towards fruit that comes from the supermarket or alternative sources such as the 'Too good to go' application in relation to their self-reported emotional reaction towards FW using linguistic terms. Data on emotion perception while throwing away food is used to calculate a consensus across the different fruit preference groups of participants. In our research, we additionally include gender and participants' prior knowledge of the application as variables during data analysis. This approach using hesitant linguistic terms was used to unveil the most pertinent emotions related to FW and was able to identify which are the emotions that are more relevant in different groups.

1 Introduction

Unsustainable consumption and production patterns are the root cause of the triple planetary crisis: climate change, biodiversity loss, and pollution. The United Nations' 2030 Agenda for Sustainable Development emphasizes 17 urgent goals (SDGs) to address these challenges. Food loss and waste have significant environmental, economic, and social consequences. Food systems alone contribute to 34% of total anthropogenic greenhouse gas emissions (GHG; CO_2, CH_4, N_2O, fluorinated gases) (Crippa, 2021), with 50% of these emissions attributed to food loss and waste (Zhu et al, 2023). Additionally, precious resources crucial for food production, including labor, energy, land, and freshwater, are being lost or wasted. Astonishingly, it is estimated that 24% of global freshwater, 23% of cropland, and 23% of total fertilizers used worldwide are being squandered (Kummu et al., 2012). This wastage also leads to land degradation through soil erosion, desertification, deforestation, and nutrient depletion (Rockström et al, 2023). Disturbingly, simultaneously approximately 800 million people suffer from hunger, and around 30% of the global population face moderate to severe food insecurity in 2021(UN, 2022).

Previous literature on FW has focused on different aspects of the issue such as the variables that affect this phenomenon. It is pivotal to understand the underpinnings of why consumers are willing to throw away food in the household as it is the main source of FW. De Hooge et al. (2017) run a big sample experiment in five Northern European countries in which participants had to decide between typical and suboptimal products of different categories. The results show that there are many factors in play such as the context of buying the products (online or at the supermarket) but also how suboptimal the product was. They also found that demographics, personality, and individual values affected their choices. Related research has been conducted in relation to potatoes in Spain (Gracia & Gómez, 2020) and citrus fruit in Taiwan (Huang et al., 2021). In a similar vein, Ponis et al. (2017) conducted a household survey in Greece

regarding the impact of different shopping habits, eating preferences and food management on FW. The difference here being that the focus was on the behavior of the consumer instead of the product'(s) characteristics.

The FW problem is multi-faceted as it entails social, environmental, and economic aspects. In the present manuscript we have taken a multidisciplinary approach that combines different techniques. We ran an in-person taste experiment where participants were offered to try two kinds of apple. One coming supposedly from the supermarket and the other one from the 'Too good to go' application. This application is a well-known platform across the European Union where users can buy surplus food at a cheaper price. This second type of apple could be considered the suboptimal one as it is potentially not as fresh. After participants tried the two supposedly different apples, they were asked which apple they preferred and to answer a short survey. Our contribution is that we have innovatively designed an experiment to capture how participants' pre-conceptions of FW affect their taste.

We are using the fruit preference experiment in combination with a series of questions regarding food waste and environmental tendencies as a proxy to understand FW behavior in a young population. The reason why we decided to focus our research on young people is twofold: firstly, it has been shown that younger people contribute more to food waste (de Hooge et al., 2017) and secondly, it was easier to recruit young participants as they were tested in the university.

In the present manuscript we have focused our analysis on emotional response to food waste. This was done because previous research highlights those non-cognitive variables of emotions and habits influence FW and there is very limited, mostly qualitative research on the topic (Rusell et al., 2017). People's perceptions about real problems may be imperfect and incomplete and several studies have considered the use of qualitative or approximate reasoning to model sensory perceptions (Castro-Lopez & Alonso, 2019). Additionally previous work has focused solely on negative emotions while we have 6 different emotions that have a negative or a positive connotation. We have also analyzed demographic information on gender as it has also been shown that females tend to contribute more to FW and previous knowledge of the application.

The methodology used in this paper moves in two directions: first, analyzing differences among emotions when in different groups of people using a statistical analysis, and then using qualitative reasoning models including hesitant terms to find a central opinion of different profiles and measuring the consensus in each one of these groups. The methodology is able to capture subtle differences in group responses that classical statistical methods were not able to detect.

The rest of this paper is structured as follows: Firstly, Sect. 2 introduces preliminary concepts on HFLTS presenting definitions of centroid and consensus, these basic concepts were already presented in a previous study (Montserrat-Adell et al., 2016). Section 3 introduces our experimental approach together with data analysis and results considering both approaches, the numerical statistical and the qualitative reasoning approach. Finally, Sect. 4 contains the main conclusions and lines of future research.

2 Preliminaries

A summary of the basic concepts related to hesitant linguistic term sets (HLTS) that will be referenced in the experimental part of the paper is presented in this section.

Let S denote a finite totally ordered set of linguistic terms, $S = \{s_1, ..., s_n\}$, with $s_1 < \cdots < s_n$, where the elements of S are considered as the basic terms, and n denotes the granularity of the model. Aligned with the concepts introduced by Rodriguez et al. (2011), *hesitant fuzzy linguistic term set* (HFLTS) over S is a subset of consecutive linguistic terms of S, i.e., $\{x \in S | s_i \leq x \leq s_j\}$, for some $i, j \in \{1, ..., n\}$ with $i \leq j$. We note $[s_i, s_j]$ to this HFLTS, or $\{s_i\} \equiv [s_i, s_i]$ if $i = j$.

Then, $\mathcal{H}_S$ is defined as the set of all possible HLTS over S excluding the empty set. In addition, we define the hesitancy of a linguistic term $[s_i, s_j]$ as $\mathcal{W}([s_i, s_j]) = j - i + 1$. In $\mathcal{H}_S \cup \{\emptyset\}$, the *intersection* $\cap$ and the *connected union* $\sqcup$ are defined as follows:

- $[s_i, s_j] \cap [s_k, s_l] = [s_{\max\{i,k\}}, s_{\min\{j,l\}}]$, if this HFLTS exists or $\emptyset$ otherwise.
- $[s_i, s_j] \sqcup [s_k, s_l] = [s_{\min\{i,k\}}, s_{\max\{j,l\}}]$.

Note that intersection and connected union are closed binary operations defined on $\mathcal{H}_S \cup \{\emptyset\}$. It is not difficult to prove that the set $\mathcal{H}_S \cup \{\emptyset\}$, jointly with the two-binary operation intersection and connected union, form a lattice (Amina and Azim, 2019).

In addition, a distance between two HLTS as defined in Porro et al. (2022). Given $H_1, H_2 \in \mathcal{H}_S$, the distance between H_1 and H_2 is defined as:

$$d(H_1, H_2) =$$

$$2 \cdot card(H_1 \sqcup H_2) - card(H_1) - card(H_2) \quad (1)$$

In addition, given a set of linguistic terms $G = \{H_1, ..., H_k\}$, we define the centroid as:

$$H^C = \arg \min \sum_{j=1}^{k} d\left(H, H_j\right) \tag{2}$$

with $H_j \in G$ that is to say the element in the lattice that minimizes the addition of the distances to all the elements of the given set G. When the set of linguistic terms G come from the opinions of a group of individuals this element is considered as the central opinion. The central opinion is the hesitant term that is most representative of all the opinions in the group. It is not necessarily one of the individual opinions, but it is able to capture global uncertainty in responses. Note that in some cases, the centroid is not a unique element Finally, the consensus among all G elements is computed by means of:

$$\delta(G) = 1 - \frac{\sum_{i=1}^{k} d(H^c, H_i)}{k(n-1)} \tag{3}$$

This consensus degree proposed by Montserrat-Adell et al. (2016) is used to quantify the opinion agreement among a set of individuals. The consensus complements the centroid as it shows the polarity of the opinions of the group. A small consensus implies low agreement among all the individuals in contrast to a large consensus where there is considerable agreement. This will allow us to compare the relevance or impact of two different aggregate opinions.

In this paper the individuals are the participants of the experiment, the variable of analysis will be the emotions, and the opinion are with respect to the emotions.

3 Experimental approach

3.1 Participants

A total of 181 participants were tested (Mean age = 19, SD age = 1, female = 97). An additional 5 participants were tested but discarded from the final sample due to technical error (n=5) and failure to complete the whole study (n=2). Participants were undergraduate students from the ESADE Business School and were given extra-credit scores as compensation for their participation. The present experiment was approved by the Research Ethics committee at ESADE (009/2023), and all data were treated confidentially. All participants signed a consent form before taking part in the experiment.

3.2 Materials

In the spirit of sustainability, we used a local Catalan variety of apples (Golden Empordà) for the experiment from a nearby market. The fruit was always freshly cut, no more than 10 minutes before the arrival of the participants. The apples were first peeled and then cut using an apple cutter to guarantee equal slices(see figure 1).

3.3 Paradigm/Experimental Procedure

We used an adaptation of the testing paradigm used in Sörqvist et al., (2013). This type of paradigm is typically used in the context of taste experiments. Deception is used given that the same product is used but labelled differently when the research question is on the drivers behind a phenomenon and not the products themselves (e.g. Liem et al., 2012 for soup). Participants were tested in a soundproof room at the Decision Lab located at the ESADE Sant Cugat Campus. They sat in a chair facing a table where two transparent bowls were placed containing the apple slices. Participants were asked to give their consent by signing a form and were asked whether they had any food allergies. Then, the experimenter asked if they had any previous knowledge of the 'Too good to go' app. Irrespective to their response, the experimenter gave the same brief description to all participants in order to make sure they all had a basic understanding of the source of the fruit. Participants were then asked to try the fruit. The experimenter labeled each bowl (supermarket/'too good to go') and offered the participants as many slices as they fancied to have a concrete idea of the taste of the apple. They were instructed to have some water between the two tastings. The order and side of presentation of the two kinds of apple was counterbalanced across participants. Following the tasting, they were guided to an adjoining room where a Microsoft Surface Tablet equipped with a keyboard was placed. Participants had to answer a series of questions privately using a survey on Qualtrics. This setting was chosen to reduce social biases based on which participants felt pressured to answer the desirable choices according to society. They had to choose which apple they preferred. They were given three choices: Supermarket, 'Too good to go' or both. Participants were asked to rate how they feel when throwing away food on a scale from 1 (Not at all) to 5 (Very much) allowing multiple answers per emotion, using the six basic emotions: angry, ashamed, happy, indifferent, guilty and sad and other questions on their behavior concerning FW and the environment. Lastly, we also asked them to fill in some basic demographic information on their gender (Female, Male, Non-binary/Third Gender, Prefer not to say), age and previous familiarity with the 'Too good to go' app. These variables are included in a bigger project that contains more questions on the profile of the participants.
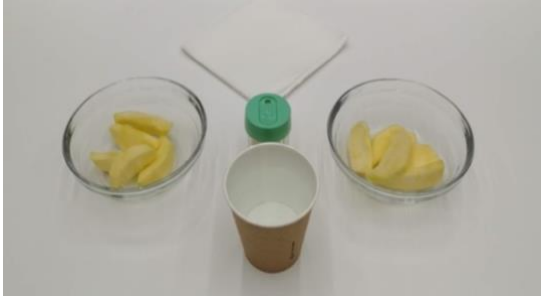
Figure 1. Experimental setting. The two alleged distinct apples were placed in two transparent bowls in front of the participants.

4 Data analysis

We analyzed the data on emotions related to food waste. Participants' evaluations were analyzed using two different approaches:

4.1 Statistical Approach

The evaluations of participants in relation to the six emotions (angry, ashamed, guilty, happy, indifferent, and sad) were treated as numerical values ranging from 1 to 5. Answers that included hesitancy, i.e., more than one value per emotion were averaged. For instance, if a participant answered that they felt ashamed 2-5, then these range was replaced by their mean which is 3.5. These values were submitted to a mixed-ANOVA as the dependent variable. The type of Emotion was introduced as a within participant factor. Three factors were introduced to the ANOVA as between: Fruit Preference (Both, Supermarket, Too good to go), Gender (Female, Male) and Previous Knowledge of 'Too good to go' (Yes, No). The ANOVA included the main effects of these factors but also their interaction.

4.2 Qualitative Reasoning Approach

The evaluations of participants in relation to the six emotions (angry, ashamed, guilty, happy, indifferent, and sad) were treated as linguistic labels considering the opinions from a lattice of HFLTS with granularity 5 where the basic terms were $S = \{s_1, ..., s_5\}$, with $s_1 < \cdots < s_5$. Answers could include basic terms or hesitancy. In this approach, if a participant answered that they felt ashamed 2-5, we considered the HFLTS as $[s_2, s_5]$ to maintain the hesitancy given in the answer. Using different levels of precision in the linguistic terms allows us to capture the hesitancy that is inherent in peoples' emotions. Then to define groups among participants we consider two partitions. The first partition was constructed from the values of Fruit Preference (Both, Supermarket, Too good to go) and Gender (Female, Male). The second partition was constructed from the values of Fruit Preference (Both,

Supermarket, Too good to go) and Previous Knowledge of 'Too good to go' (Yes, No). Twelve groups were defined and emotions among these groups were compared. To this end, the centroid and consensus were computed and differences among groups were considered following equations (2) and (3).

5 Results

Out of the 181 valid participants, 70 (38%) had no apple preference as they chose both apples, 63 participants preferred the 'Too good to go' apple (34%) and 48(27%) preferred the Supermarket apple. Out of the 181 participants, 97 identified as Female and 125 participants had previous knowledge of 'Too Good to go'.

5.1 Statistical Approach

A Mixed design ANOVA has several assumptions that should be met. In the presence of multiple factors, we checked for approximate normality of the residuals of the model using a qqplot. The data did not appear to be skewed after visual inspection. Levene's test was used to check for homogeneity of variance because of the between-subjects design. Only one violation was found between males and females for the emotion 'happy' ($F_{(1,178)} = 4.67$, $p = .032$).

A significant effect of Emotion was found ($F(3.35, 566.13) = 119.20$, $p < .001$, $\eta_p^2 = .41$) (see table 1 for descriptives). Meaning that the evaluations to the six emotions regarding food waste were different. This is an expected finding as one would expect low values for happy and indifference while higher values for angry, ashamed, guilty and sad. The interaction between Emotion and Previous Knowledge (see Figure 2) was also significant $F(3.35, 566.13) = 3.51$, $p = .012$, $\eta_p^2 = .02$. Lastly, the interaction between Emotion and Gender (see Figure 3.) was also found statistically different $F(3.35, 566.13) = 3.75$, $p = .008$, $\eta_p^2 = .02$. We performed post-hoc analysis on the statistically significant interactions. Due to the very high number of comparisons (sixty-six in each case), we decided to not add them in the main paper as they are not directly relevant to the hypothesis. Overall, most of the comparisons were significant (please see figure 2 and figure 3 for visual comparisons).The main effect of Fruit Preference, Gender, or Previous Familiarity in addition to the rest of the interactions not mentioned above did not reach statistical significance.

Table 1. Descriptive summary of the main effect of Emotion

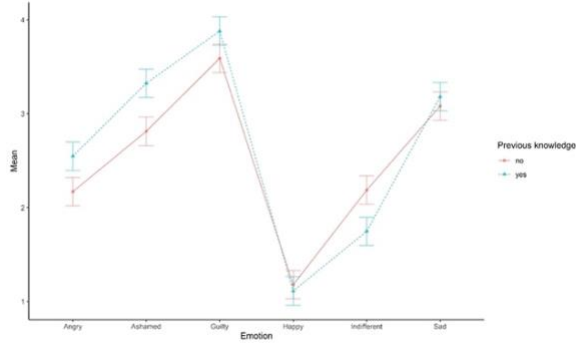|	Emotion					
	Angry	Ashamed	Guilty	Happy	Indifferent	Sad
Mean	2,42	3,17	3,79	1,13	1,88	3,15
SD	1,22	1,21	1,10	0,41	1,10	1,26

Figure 2. Mean evaluations of the six emotions while throwing away food and their error bars (Fisher's Least Significant Difference was used to enable within-Ss comparisons) are shown. The red line shows the values for the people who had no previous knowledge of 'Too good to go', while the blue one stands for the people who have previous knowledge.
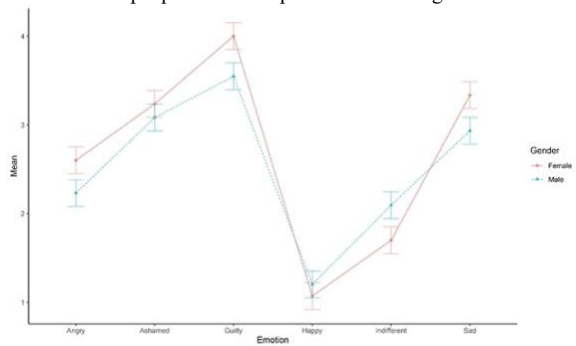

Figure 3. Mean evaluations of the six emotions while throwing away food and their error bars (Fisher's Least Significant Difference was used to enable within-Ss comparisons) are shown. The red line shows the values for the people who self-identified themselves as Female, while the blue one stands for the people who self-identify as Male.

5.2 Qualitative Reasoning Approach

Differences among emotions were found between the centroids with respect to the groups. In the first partition, differences between male and female were detected for all emotions except happy. For example, with respect to the emotion angry, males who preferred the Supermarket product are represented by a centroid of [2,2]. This indicates that their central opinion is a 2 when considering the scale from 1 (Not at all) to 5 (Very much) and it does not reflect any hesitancy when considering the opinion of the group as a whole. In contrast, females who preferred the Supermarket product are represented by a centroid of [2,3], indicating that their central opinion ranges from equal to slightly higher than that of males with the same produce preference. As their central opinion is formed by a range, it captures the hesitancy in the opinion of the group.

Table 2. Comparison of centroid emotions (partition 1)

	Emotion											
	angry		ashamed		guilty		happy		indifferent		sad	
Fruit Preference	M	F	M	F	M	F	M	F	M	F	M	F
Supermarket	[2, 2]	[2, 3]	[2, 2]	[4, 4]	[3, 3]	[4, 4]	[1, 1]	[1, 1]	[2, 2]	[1, 1]	[2, 2]	[4, 4]
Supermarket,Too good to go	[2, 2]	[2, 2]	[3, 3]	[3, 3]	[4, 4]	[4, 4]	[1, 1]	[1, 1]	[1, 2]	[1, 1]	[3, 3]	[3, 3]
Too good to go	[2, 2]	[3, 3]	[3, 3]	[4, 4]	[4, 4]	[5, 5]	[1, 1]	[1, 1]	[2, 2]	[1, 1]	[3, 3]	[4, 4]

In the second partition, differences between Too Good To Go familiarity were detected for all emotions except happy and guilty.

Table 3. Comparison of centroid emotions (partition 2)

	Emotion											
	angry		ashamed		guilty		happy		indifferent		sad	
Fruit Preference	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Supermarket	[2, 3]	[2, 2]	[4, 4]	[2, 2]	[4, 4]	[4, 4]	[1, 1]	[1, 1]	[1, 1]	[2, 2]	[4, 4]	[2, 2]
Supermarket,Too good to go	[3, 3]	[2, 2]	[3, 3]	[3, 3]	[4, 4]	[4, 4]	[1, 1]	[1, 1]	[1, 1]	[2, 2]	[3, 3]	[3, 3]
Too good to go	[2, 2]	[2, 2]	[4, 4]	[3, 3]	[4, 4]	[4, 4]	[1, 1]	[1, 1]	[1, 1]	[2, 2]	[3, 3]	[4, 4]

Finally, we computed the consensus corresponding to each group and emotion. In both partitions, we obtained values greater than 0.7 which is considered to be a high consensus given the granularity. Note that the consensus is considered from [0,1], therefore, this value indicates that there is little polarity in the opinions.

6 Conclusions and Future Research

There are several crucial outcomes shown in this paper. First of all, comparing the different results obtained when using classical statistics, we detected the tests were not able to find differences across the distinct preference groups (supermarket, supermarket/too good to go, to go to go) based on their emotional evaluations, whereas with our analysis based on qualitative hesitant terms it was possible. Secondly, both types of analyses were able to replicate previous findings on FW, since we found differences based on gender in relation to emotional responses. We have also extended previous work on FW since we investigated the interplay between previous knowledge of 'Too good to go' or gender identity on emotional valence. This approach has not been taken before as far as we know. We found that participants who have had previous knowledge of the 'Too good to go' app or are Female are more likely to rate higher in the negative emotions and lower in indifference. Thirdly, the combination of experimental methods with qualitative research is an approach that allowed us to gain a more nuanced understanding of the emotional issues connected to FW by separating perception from biased thought and connecting the resulting preference groups to salient emotions. Finally, we applied the interdisciplinary approach to the field of FW. This work represents the initial results of our efforts to comprehensively understand the drivers, emotional aspects, behavioral patterns, and cognitive factors connected to food waste. We believe these findings pave the way for further exploration and might have practical implications for policy.

Acknowledgments

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