One Byte at a Time

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One Byte at a Time: Insights about Meaningful Data for Sustainable Food Consumption Practices

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Data have played an extensive role in sustainable HCI research by informing the impacts of our behavior on the environment and helping us make better environmental choices. However, in the area of sustainable food consumption and sustainable HCI, there is little investigation on the roles of food data for the design of technology. This paper presents findings from a qualitative study of sustainable-conscious individuals' food data seeking experiences. Our results show the way in which the current food data is challenging our understanding of its environmental impacts, which concern data of availability, data representations, and data cultures. Drawing from Loukissas' six critical data principles, we discuss how "locality" and "place" could cast a new insight on food and its sustainability. We also offer possible design directions for sustainable HCI technologies utilizing food data.

CCS Concepts: • **Human-centered computing → Empirical studies in HCI**.

Additional Key Words and Phrases: Sustainability; sustainable; food; consumption; data; sustainable HCI; sustainability-conscious;

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1 INTRODUCTION

Our current food consumption is challenging for the sustainability of our planet [62]. Food systems (production, supply chain, retail, and consumption) create approximately 13.7 billion tons of carbon dioxide equivalents (CO2 eq), or 26% of all anthropogenic emissions [63]. The problem extends all the way from environmentally unsustainable farming, to extensive supply chains, and to the fact that almost one third of all food ends up as waste according to Food and Agriculture Organization (FAO) of United Nations [42].

In the Sustainable HCI community, food has also played an increasingly important role in recent years [9]. Scholars have studied multiple areas of food, such as food waste [73], smart farming [70], awareness of organic [75] and local food [58], food miles [49], and more. Most work has been carried out in relation to food waste (e.g.,[2, 15, 16, 33, 34, 44, 57, 69, 73]), but the consumption aspects have also increasingly gotten attention (e.g., [45, 47, 75]). This increase is partly because food consumption, and all the many processes contributing hereto, is viewed as a key sustainability

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challenge [62] and also because it is becoming possible to collect and use food consumption data in order to address sustainability problems [63, 64, 75].

Previous HCI research has shown that environmentally-conscious people spend considerable resources to gain insight into the sustainability of food products for purchasing in a sustainable way [23]. To support such efforts, a wide variety of technologies have been introduced, including carbon footprint calculators, smartphone apps that support people to make sustainable decisions in e.g., supermarkets, and numerous websites on food sustainability information. Previous research has also focused on supporting sustainable food choices while shopping (e.g., [45, 50]), as well as reflecting after shopping [10]. Despite all these activities and studies, there is little investigation on the roles of food data for the design of technology, specifically how food data may play a role during planning, carrying out, and reflecting about food purchases, and what data become meaningful in making sustainably informed choices in the context of food.

In this paper, we seek to gain insights into the relation between meaningful data for sustainable food practices and how data-driven design can support individuals in being sustainable. Our aim is to examine sustainability-conscious individuals' food consumption related to food data in its whole, without scoping on a specific context or process. To do so, we investigated the current food data practices of these people through multiple qualitative interviews and the deployment of a probe that was designed to spark reflections about which data are meaningful for practicing sustainable food consumption. This paper makes a three-fold contribution to the body of HCI and design research: First, we present empirical findings on the meaningfulness of food data that emerged from individuals who are deeply engaged in sustainability. Our results show the way in which the current food data is challenging our understanding of its environmental impacts, which concern the data of availability, data representations, and data cultures. Second, drawing from Loukissas' six critical data principles, we discuss how these principles, including the concepts of "locality" and "place", could cast a new insight on food and its sustainability. Lastly, we offer possible design directions for sustainable HCI technologies utilizing with food data.

2 RELATED WORK

Ever since Eli Blevis in 2007 [8] pioneered with his work within sustainable HCI, multiple attempts at promoting sustainability through design of technology have seen the light of day. This is also evident in relation to food consumption. The following unfolds the characteristics of sustainable food consumption and the complexities of practicing it. Furthermore, we provide an overview of the landscape of technology designs for supporting sustainable food consumption. Lastly, we review the role of data in everyday life and in sustainable food practices. These three areas of research cover both the practice aspects of sustainable food consumption and the technological aspects that are relevant in order to situate our study into a broader research context.

2.1 Sustainable Food Consumption in HCI

Sustainable food consumption is one of the sustainable HCI research agendas that encompasses processes for or aspects of food. For example, how the different processes such as agriculture, production, processing, supply chain, retail, purchase, and waste affect the sustainability of a food item [62]. Sustainable food consumption also deals with multiple aspects of food, such as organic food [75], local food [55], climate footprint of food [21, 22, 26, 68], food management and awareness [5, 46], food miles [49], and a large amount of work in food waste, (e.g. [2, 32, 34, 57, 69, 73]). The many different processes involved in food consumption (agriculture, supply chain etc.) and the aforementioned aspects of sustainable food makes practicing it both time-consuming and complex for sustainability-conscious individuals [23], seeing that all these factors need to be considered by these people.

Clear and Friday [20] note that sustainable food consumption practices can be seen as a: *"[...] mish-mash of vaguely related practical and moral concerns, choices and dichotomies [...] reflecting the various ways in which the activities of shopping, cooking and disposal are interwoven with other complex social and familial responsibilities and obligations."* [20]. Additionally, Clear et al. [23] find that shopping practices differ immensely between that they call "mainstream" shoppers and sustainability-conscious, or "pioneer", shoppers. Where the vast majority of mainstream shoppers are concerned with price and convenience [23, 45, 49], the sustainability-conscious shoppers are more concerned with locality, organicity, or food miles and that almost all of them regularly shop or acquire food from places other than the supermarkets (stores specializing in ethical and organic food, and food box deliveries) [23]. Clear et al. [23] stress the importance of learning from these "pioneer" food shopping and consumption cultures, both when considering the practices of food consumption and when designing technology for sustainable food.

Some HCI researchers have sought to accommodate for this complexity by offering assistance for the individuals when choosing what food to buy [21, 45, 48, 49, 59, 68, 75]. Herbig et al. [45] developed ten guidelines for assistance systems supporting sustainable food shopping, whereas three of them were found especially relevant: *"[...] coverage of multiple sustainability dimensions, personalization possibility, and an intuitive understandable visualisation and interaction."* [45]. "Coverage of multiple sustainability dimensions" concerns that individuals most often specify at least two aspects (e.g., product labels, and catch methods for fish) as meaningful for assessing whether or not an item is sustainable. "Personalization possibility" covers that sustainability always is a trade-off between multiple aspects and that individuals therefore often value differently. Lastly, "intuitive understandable visualisation and interaction" infers that despite the complexity of sustainable food, a system should provide easily understandable visualizations and interactions. Their study has a rather strict focus on point of sale, which we in this study seek to broaden by looking at the practice of sustainable food consumption as a whole. Clear and colleagues [21] also discuss their lessons learned in relation with supporting sustainable food shopping. They argue that there are major limitations in making sustainability only a question of information and rational choices. Rather, it is a combination of social (family size, taste preferences etc.), technical (online or physical shopping, budget etc.), and infrastructural (time for doing shopping, means of transportation etc.) factors [21]. Although the lessons learned provided by [21] bring valuable insights for studying sustainable food, we aim at a more elaborate focus on the role of data in these practices.

2.2 Technology for Sustainable Food Consumption Practices

Visualizing data has been a way that the majority of technology utilize to make people choose more sustainable. An early example of design to promote sustainable food choices is that of Linehan et al. [59]. They presented a system that allows for image uploading and tagging in a social media context. The tags are meant to give the individuals an understanding of their own food choices [59]. Kalnikaite et al. [49] based their approach on in-situ informing decision-making and nudging shoppers regarding sustainable grocery items. Their study is not exclusively devoted to sustainability, however sustainability in the shape of food miles and organic food are two of the aspects that are investigated. They developed a shopping handle prototype to visualize food data and provide individuals with a greater understanding of sustainability related aspects of their grocery items [49]. A somewhat similar system is presented by Kallehave et al. [48], although in the context of promoting healthy food consumption. They stress that the persuasive shopping trolley that was developed resulted in reflection by the shoppers, however that reflection did not result in behaviour change towards more healthy food choices [48]. Zapico et al. [75] developed EcoPanel (an eco-feedback visualization tool for organic food consumption) and study how this bridges the gap between attitudes and behaviour for individuals in relation to sustainable food consumption. Their findings suggest that eco-feedback visualization of food

consumption data has possibilities for individuals to act more sustainable [75]. Another way of visualizing sustainable food consumption is described in [68]. Here, the focus is on the climate impact of different dietary choices where the authors use shared physical representations of data, the so-called Econundrum, to provide individuals with insights about the sustainability of their dietary choices [68]. Through their field study of Econundrum, they provide individuals with an understanding of the climate impact of their dietary choices and as a result increase their environmental awareness [68]. In the following we will present work in two distinct areas of sustainable food (sustainability labelling, carbon footprint calculation), where data play, or are anticipated to play, a large role.

2.2.1 Sustainability Labels. Sustainability labelling presents another branch of using and visualizing sustainability related food data [19, 40, 47, 54, 74]. For the sake of consistency, the term 'Sustainability labelling' will be used as an umbrella term for: eco-labelling, environmental impact labelling, carbon labelling etc. Leach et al. [54] discuss the possibility of a sustainability label for food products that incorporates carbon, nitrogen, and water footprints in tandem, seeing that nowadays environmental impact of food production and consumption often is invisible for consumers. While they found that beef had the largest combined carbon, nitrogen, and water footprints, and starchy roots the lowest footprint, calculation of footprints is not that simple. In cases where the calculated footprint was compared to nutritional values, such as calories or protein, products that had a low footprint pr. kilo (e.g., vegetables, fruits) had a large footprint pr. calories or protein [54]. Also, Leach et al. [54] stress the importance of providing context and comparison options, highlighting that *"most consumers will not know, for example, the impact of 1 kg of CO2-eq on the environment."* [54]. Additionally, Cho and Baskin [19] suggest that sustainability labels should be coupled with nutrition and health labels to become more relevant, as sustainability is not the top priority for most consumers.

2.2.2 Carbon Footprint Calculators. Another way of using data for assessing the sustainability of food is through carbon footprint calculators (CFCs). CFCs are used for calculating how much CO2 a product produces through its different stages –from agriculture, through supply chain and to purchase. Traditionally, food sustainability information has been provided to the users through index charts or web-based tools [61], for example Eaternity [28], BBC's food impact calculator [7], and Agri footprint [1]. Recently, a greater focus has been placed on the use of smartphone devices as mediators for this information. This shift offers new contexts and ways of interacting with data about food consumption. Applications (apps) such as Svalna [3] and My Climate Action [29] brought general purpose CFCs into the context of smartphone technology. Specifically to sustainable food consumption, apps such as CO2food [24] and the CO2 tracker feature in Coop's shopping app [25] have recently emerged in the Scandinavian context where this study is situated.

In summary, data have been used for multiple purposes in relation to sustainable food consumption –for example, displays in the grocery store, carbon calculators in the pockets of people, and sustainability labels stuck on the products. The following will unfold how we, with a critical data perspective, can create more meaningful data practices for sustainable food.

2.3 Thinking Critically about Data

In recent years there has been a growing interest in critical data studies (e.g., [11, 27, 43, 52, 60]). An interest that can be traced back to feminist scholars and in particular Donna Harraway and her critic of objectivity as being a "conquering gaze from nowhere" that is not possible [43]. Latour and Woolgar [53] show in their study on laboratory work, how scientific facts are inscribed rather than autonomous, yet the context is hidden by their creators. In 1999, Latour [52] introduces the term "black box" which encompass: *"[...] the way scientific and technical work is made invisible by its own*

success." [52]. He argues that the internal complexity of technology becomes invisible as a result of technological and scientific success. In order to understand the underlying mechanisms, there is a need to open such black boxes and examine the parts that constitute the whole [52]. This process of examining "parts" to understand the whole is also the study focus of the work by Dourish [27]. He explores information representation in computer systems by carefully looking at the individual pieces that make up e.g., databases and network protocols. By doing this, he shows how the material constraints of data-intensive technologies shape us as humans, as the available data influence what we can know about the world [27].

Recently following by Dourish, Loukissas provides six principles for thinking more critically about data in our everyday lives: All data are local; data have complex attachments to place; data are collected from heterogeneous sources; data and algorithms are inextricably entangled; interfaces recontextualize data and; data are indexes to local knowledge. He argues that the notion of data universalism places practitioners at the periphery of a new kind of colonialism and that there is a need for alternative ways to view data by situating them into the context in which they are collected and used [60]. When using terms such as "local" or "place" as attributes for thinking about data, this reveals the social, technological and spatial nature in which data are collected, used, and represented. The six principles are meant as a framework to see the data that we are presented with in a critical way rather than merely taking them as facts [60], which seems more important than ever in a world that fuels so heavily on data.

Data play an extensive role in sustainable food consumption practices by e.g., informing sustainable rationalization [45, 49], nudging or persuading sustainable behaviour [49, 59], and publicly displaying the impact of food choice in relation to sustainability [68, 75]. Sustainable food data vary in form (qualitative or quantitative), producer (primary, secondary etc.), and structure (structured, semi-structured, or unstructured) among others [51]. In addition, they are present in different contexts, such as in grocery stores, online, at home, and in the public sphere. Sustainability-conscious individuals tend to spend large amounts of time examining data concerning their food in order to live in a sustainable way [23]. Researchers and industry have attempted to lessen the burden of living sustainable in regard to food through technology and labelling (e.g., [19, 45, 54]). However, little research has focused on meaningful data for practicing sustainable food. Therefore, this study sets out to investigate in depth what data sustainability-conscious individuals find meaningful in making sustainable food choices and also which are the current barriers for this. By drawing upon critical data studies, we aim to bring new perspectives on sustainable food data.

3 METHOD

In this study, we were particularly interested in sustainability-conscious individuals and we wanted to study their experiences with data within the frame of sustainable food practices. The following subsections unfold in detail the methods and procedures for this study.

3.1 Participants

The study participants consisted of 16 (12 female/4 male, self-identified as such) individuals with their ages ranging from 23 to 71 and a mean age of 44 years. The participants came from different regions in Denmark, although mostly urban areas. Two of them lived in the countryside. In table 1, we detailed the participants' demographics. The 16 participants were recruited through postings on the three biggest online social media groups about sustainable consumption practices in Denmark: a) "De baeredygtige klimaløsninger" (The sustainable climate solutions, 4,448 member); b) "Bæredygtighed for Alle" (Sustainability for All, 17,403 members); and c) "Bæredygtig Livsstil" (Sustainable Lifestyle, 3,001 members). They all volunteered for the study and fulfilled the inclusion criteria of being actively engaged in sustainable food

practices on a daily basis, 18 years or older, and doing grocery shopping on a regular basis. We specifically chose to recruit sustainability-conscious individuals, since their practices have the possibility to provide of us with valuable knowledge about sustainable food [23]. To better understand about our participants' engagement with sustainability issues, we asked them to fill out the Sustainability Consciousness Questionnaire Large (SCQ-L) [37]. While SCQ-L measures a variety of sustainability aspects, such as social, economic and environmental sustainability [37], we only chose an environmental sustainability module consisting of 17 statements on a agree/disagree scale. An example SCQ-L statements is: "I always separate food waste before putting out the rubbish when I have the chance" [37], and the highest score an individual can have is 17. While the use of SCQ-L provided us with an understanding of the participants' engagement in sustainability issues, we also discussed heavily with the participants during the interviews how they perceive, define and practice sustainability. The various ways of doing so are portrayed in the findings (e.g., section 4.1.1).

Participant	Age	Occupation	Years engaged in sustainable food practices	SCQ-L score
P1	68	Pensioner	3 to 5 years	14
P2	71	Pensioner	3 to 5 years	13
P3	29	Student	5 to 10 years	14
P4	50	Pensioner	10 years or more	15
P5	26	Unemployed	5 to 10 years	15
P6	45	Employee	10 years or more	14
P7	48	Employee	10 years or more	15
P8	45	Employee	5 to 10 years	17
P9	34	Self-employed	5 to 10 years	11
P10	47	Employee	10 years or more	15
P11	23	Student	3 to 5 years	14
P12	48	Employee	5 to 10 years	13
P13	53	Stay-at-home partner	10 years or more	12
P14	42	Part-time employee	10 years or more	15
P15	41	Part-time employee	2 years or less	9
P16	43	Employee	10 years or more	16

Table 1. Demographic of the participants, including how many years they have been engaged in sustainable food practices and their SCQ-L score.

3.2 Study Procedure and Data Collection

The study involved three distinct phases where we engaged with the 16 participants and collected data about their sustainable food practices: an initial interview, the deployment of a shopping probe, and a second interview. All interviews were conducted in Danish and translated to English by the authors.

3.2.1 Initial interview. The initial interview concerned the participants' grocery shopping practices, their stance towards sustainability in general and specifically to food, and their view on data and/or information concerning sustainable food. Additionally, we also gained insights about how they perceive and define sustainability, and many years they have been engaged in sustainable food practices (see table 1). At the end of the interview, the participants were instructed to

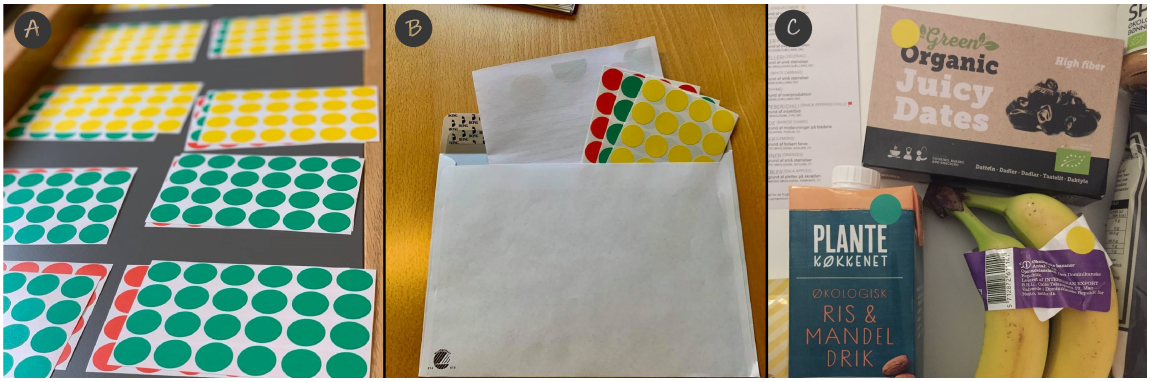

Fig. 1. From left to right. The stickers being prepared for participants. The probe containing the document and the stickers. Food items with the aforementioned stickers put on them.

use a shopping probe in connection to one of their next grocery shopping trips and report back to the authors when they had done it in order to schedule the second interview.

3.2.2 Shopping Probe. The shopping probe aimed at making the participants reflect upon what kinds of data they look for (or miss) when evaluating the sustainability of their food purchases and to which degree they feel informed about whether their food purchases are sustainable. In accordance with Gaver et al. [35], the probe was designed to be open in regard to interpretation and inviting the participants to return data that were less constrained than other data gathering methods. In developing the shopping probe, we were inspired by the work of Kalnikaite et al. [49]. Our shopping probe consisted of small stickers (Figure 1A) in three colors (red, green, and yellow) and a document with an exercise. The probe was sent to our participants in sealed envelope by post (Figure 1B). Unlike Kalnikaite et al. [49], we instructed our participants to open the sealed envelope after a larger grocery shopping trip (minimum 30 dollars spent), hoping that by keeping them blind for the probe's purpose, they would not alter their shopping behavior. Furthermore, our setup allowed the participants to choose freely when and where to do their shopping and use our probe, which resulted in the probe deployment lasting between two and four weeks.

When the grocery shopping trip was completed and the participants came home, they opened the sealed envelope and read the instructions in text on the left column of the document (Figure 2). It asked them to put stickers onto their newly purchased grocery items according to how sustainable they considered them to be. A green sticker was to be used if the participant perceived an item as sustainable and a red sticker was to be used if it was not sustainable (e.g., Figure 1C). The yellow sticker was to be used if the participant was in doubt about the sustainability of a specific item. When each of the purchased items was marked with a sticker, the participant turned to the right column of the document and noted down their reflections about why they chose a specific color sticker as opposed to another (Figure 2). In order to assist their reflections, one question for each color was provided.

After the participants completed the exercise, they were asked to take pictures of the food items that they had bought and marked with stickers (see figure 1C) along with their reflections and send them to the authors to be used in the second interview.

3.2.3 Second Interview. The second interviews were based on the outcomes of using the shopping probe and they were semi-structured using an interview guide that embraced these outcomes. The pictures taken by the participants

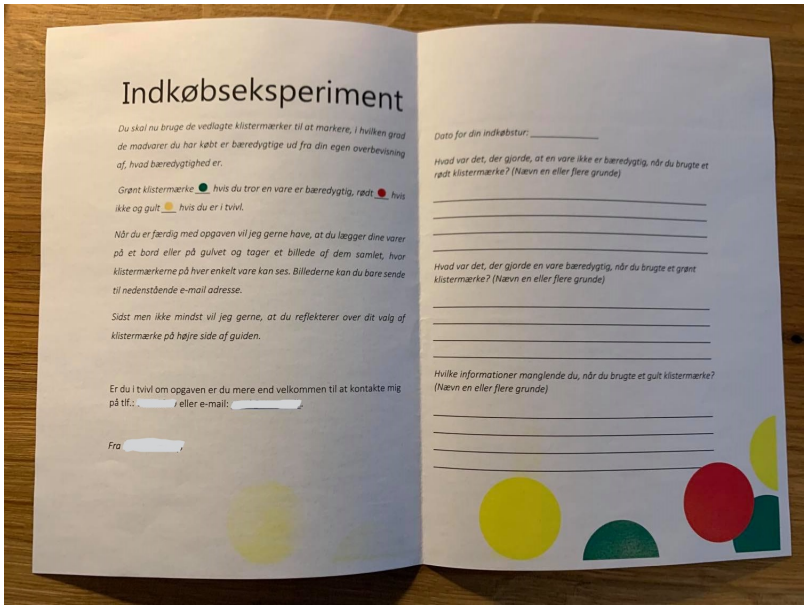

Fig. 2. The two columned document with instructions for use on the left side and the questions to each color of sticker on the right side: "When choosing a red sticker, what was it that made a specific food item not sustainable? (Choose one or more reasons).": "When choosing a green sticker, what was it that made a specific food item sustainable? (Choose one or more reasons).": and "When choosing a yellow sticker, what kind of information were you lacking in order to make more confident choice? (Choose one or more reasons).".

"sparked a dialogue" in the words of Gaver et al. [35] between each participant and the researchers and offered a rich account of both spoken and unspoken aspects of participants' understanding of sustainable food data. An example of this was that animal products in general were given a red sticker. In addition to discussion topics that were generated based on the shopping probe, the second interview also focused on how and which data could become meaningful in relation to sustainable food consumption and how this can inform new ways of designing technology.

3.3 Data Analysis

Besides analyzing the collected SCQ-L data, most of the data analysis efforts revolved around the interviews. Interviews lasted on average 45 minutes and were conducted either through telephone or computer mediated communication software. All audio recordings for both interviews were fully transcribed and analyzed through thematic analysis as described in [12]. Bryman [12] identifies a central shortcoming of thematic analysis to be that the word 'theme' is interpreted in various ways. To accommodate for this shortcoming, we drew inspiration from Ryan and Bernard [66] who recommend looking for eight distinct aspects when identifying themes such as repetitions, categories, analogies, transitions, and similarities and differences. In the initial part of the analysis, we coded different parts of the transcripts. The next part of the analysis was based on the 'framework' method for assisting thematic analysis [65]. We constructed an index of themes, represented in a matrix, which displayed participants on the horizontal axis and themes on the vertical axis. The coded data was transferred into this matrix, that took form of a large spreadsheet, and categorized with respect to theme and participant. Furthermore, the images and written reflections from the shopping probe were coded as well, as they supported the thematic analysis of the interviews by adding richer perspectives to the findings through

visual accounts and elaborations on participants' reasoning. We identified a total of four themes with sub-themes from the data and we will detail them in the next section.

4 FINDINGS

The findings section touch upon the practices of sustainability-conscious individuals around food data and what data become meaningful to them. We identified the way in which the current food data is challenging our understanding of food and its sustainability, which interact with the data accessibility, transparency, provenance, and data cultures.

4.1 The Complexity of Sustainable Food Consumption Practices

While our participants have a strong engagement in sustainable food consumption, how they practice it is not by any means straightforward. All the participants told us that they spent a lot of time on sustainable food consumption and made substantial changes to their way of living, such as shifting their dietary to exclude any animal products or starting to dumpster dive. While most of our participants (N=14) chose to be vegetarians, vegans or in other ways eat plant-based, P14 additionally made her own rules to make her food choices sustainable all around. P14 said *"We live primarily in a vegetarian way, but with a little fish. It is very rare that we even buy meat and if we do then it must be price reduced and it must be organic [...] We felt that we cheated but then we thought that it would end up as food waste if we do not buy it. Therefore, we made a rule that we are allowed to buy it"* (P14). Sustainable food consumption is not a straightforward choice, it requires continuous negotiations around how sustainability was perceived by the participants.

4.1.1 Different Motivations for Sustainable Food Consumption. While all participants follow sustainable practices, their understandings differ in what the term "sustainability" encompass. For example, P16 told us: *"I struggle with finding a definition for sustainability where it is possible to say 'Now we agree what it means!'. And that is because I think there are very different understandings of the term"* (P16). Although sustainability was viewed upon as a complicated term, there was an agreement between the participants that the environmental part of sustainability was the driving factor for them, as P8 expressed: *"If we think about the typical forms of sustainability, [they would be] economic, environmental, and social. I am probably mostly in the environmental part. And I think that I am clearly in the risk of getting some sort of depression because we are not further than we are <laughter>"* (P8). With this tragicomic statement, P8 showed that the environment was the main factor for her engagement in sustainability.

While environmental sustainability was a shared motivation among all of our participants to practice sustainable food consumption, they expressed differences in their focus. Climate change was the primarily focus for some participants (N=3), for example P12 told us that *"The main priority for me is that we reduce fossil emissions and greenhouse gasses, which entails that we all take responsibility and do something about it. This is for example why we almost never eat any kinds of meat in this house"* (P12). P9 noted that animal welfare was the main reason for her transition to sustainable food consumption. P9 explained her stance in the following: *"People talk a lot about CO2 emissions and all that, but for me the important aspect of sustainability is animal welfare."* (P9). The rest of the participants tended to embrace multiple focuses on sustainable food, as expressed by P2: *"It is not only organic food or climate change that is important. It is a mix of it all. [...] It is also animal welfare on top of that."* (P2). P3 philosophically manifested her motivations: *"With time it has become more of a sustainable way of being kind of thing"* (P3). We found that the participants' different and evolving understandings and engagements in sustainable food consumption shaped what kinds of data and information could become meaningful for them (we will detail this later).

4.1.2 Modifying Shopping Practices for Sustainable Food. Our participants had varying shopping practices, both with respect to the frequency and mode of grocery shopping. These differences were also closely related to their perceptions of sustainable food consumption. For example, while the participants did grocery shopping between three to four times a week on average, some participants (P7, P11, P15) did grocery shopping less than once a week, mainly due to the fact that they went dumpster diving on a regular basis, which covered a large part of their food needs. In respect to the mode of shopping, the participants represented a mix of physical and online grocery shopping depending on their needs for sustainable foods. Some participants (P8, P14, P16) drove to their local farm for groceries because all of food data are transparent and tangible: *"We started getting vegetables at the organic farm shop, because then we know that it is produced organically, it is local, it is not transported, and it is based on the season"* (P14). The other participants told us that they do a mix of physical shopping and online shopping to buy the right sustainable food for them. This included online grocery shopping, online food box delivery services, and online sustainability specialty shopping (e.g., plant-based food). The shifting shopping practices from mostly physical to a mix of physical and online are notable, seeing that most studies in sustainable food and HCI have focused solely on physical shopping practices (e.g., [45, 49, 68]. On the one hand, it can bring food further away from the sustainability-conscious individuals, resulting in the embodied experience of the food being diminished. On the other hand, it can allow for new interactions with data in order to act in a more sustainable ways, as data to a larger degree are digitized.

4.2 Gaining Knowledge about Sustainable Food Products

For our participants, the current food labels are very problematic to get meaningful data from, especially in relation to transparency.The process of gaining knowledge about sustainable food products is a rather large part of the participants' practice. We now detail our participants' data practices for sustainable food consumption.

4.2.1 Searching for Food Data. The vast majority of the participants (N=15) spent time on a regular basis searching for information about sustainable food consumption. P4 elaborated on this topic: *"It [sustainability related food information] is something that you have do active searches for. It is not something that is handed to you. [...] And I think that people who do not have the same amount of time for searching as I do would be lost in it"* (P4). P1 also invested time in searching for the right information: *"[...] we have had problems finding out how bad some things are for the climate. There are things that we really had to search long and hard for, lobsters and shrimps for example. Why are they not sustainable whatsoever? [...] We really looked for that for a long time"* (P1).

The participants used the knowledge that they had accumulated over their years of engaging in sustainable food consumption to understand and interpret the available data from food labels in the grocery store. For example, P10 said that *"I have a bunch of standard values on the climate impact for different products and then I can compare. Since I have acquainted myself with which products are the worst, then I can eat less of them, tomatoes for example"* (P10). Not all participants used distinct numeric values for their food, but they all had a large knowledge bank that they had built up over the years, concerning which items were good and bad in respect to sustainable food consumption: *"Well I would look at the knowledge that I possess and that is of course not 100 percent, but then I have a baseline and then I would search for information about the product at the places where I buy them by looking that the packaging"* (P1). As it was mentioned by P1, gaining insight into sustainable food consumption is a process that does not only take place in the grocery store. Rather, it is a combination of accumulated knowledge over time and available data in the stores.

Sustainable food data usually come from heterogeneous sources (e.g., producers, communities, retailers, interest groups, the government), which impacts the data accessibility and forms of data in many ways. P5 reflected how

heterogeneous data sources inevitably make food data complicated: "It [displaying climate footprint on food items] is easier for those who produce food that has a low carbon footprint like producers of oat milk. Opposed to meat producers who probably have very large footprints, which might scare off people from buying." (P5). Other sources of information for the participants were through their social circle or personal network, such as friends, family, communities, and colleagues. For example, some of the participants (P6, P8, P9, P10, P12) mentioned that their colleagues have been main informers: *"I have become even more aware after I met Rita [P6' colleague]. She has given me a better understanding of the importance of sustaining things, you know recycling etc. [...]"* (P6). Moreover, half of the participants (P2, P3, P4, P7, P8, P12, P14, P16) used online communities on a regular basis to share and discuss information related to sustainable food consumption. P4 enjoyed its collaborative mechanisms for sharing sustainable food knowledge, saying *"The communities are good because if one person has figured something out then they can tell the community and vice versa. In that way we do not all have to reinvent the wheel"* (P4). Engaging in communities online also allowed to broaden their perspectives on the topic: *"I get inspiration from others and I become aware of those blind angles that we all have"* (P7).

Despite the positive experiences with online communities, some participants (P4, P10, P12, P14) were especially concerned about the trustworthiness of sustainable food data and information, which led them to actively search through governmental channels and research reports: *"I have found climate reports from Concito [note: A Danish sustainability think tank] and The Technical University of Denmark so that I can reduce my climate footprint based on reliable and trustworthy knowledge."* (P12). They also explicitly mentioned that governmental intervention is necessary to streamline information about sustainable food consumption: *"If the government agencies would streamline information, then I could spend less time on searching."* (P5). The process of searching for information was rather unstructured, however the participants each had a few to-go sources of information for gaining knowledge.

4.2.2 Lack of Transparency in Food Labelling. Searching actively for information about sustainable food consumption was deemed necessary by all participants, since the current data and/or information on food labels are problematic in identifying sustainable foods. P1 exemplified this from his personal experience during grocery shopping: *"[...] then they [the retailers] write 'citrus fruits from a foreign country'... well yes of course that is obvious. It does not tell me that much. I would like to know where they are from then"* (P1). P1 was not able to decipher which country the citrus fruits came from and that was important for him, since the country has impact on production methods and transport. This discouraged him from buying the citrus fruits without knowing more about the context of them. Among others, P8 elaborated that she referred to a general lack of transparency in relation to sustainability measures: *"It is a jungle of information meaning that there were several of the items I bought [...] that I could not see where came from, how they were transported, and so on.[...] The transparency is missing. I can not see how much water is used and where it is produced. And what about transport?!"* (P8). While lacking transparency in relation to sustainability was a general issue for the participants, it revolved mainly around provenance of the food: *"In general, data regarding supply chains and production are extremely hard to come by if you are looking for it while in the shop"* (P12). For P3, identifying food provenance was necessary to figure out life cycles of the food products: *"I think about life cycles when I shop. I look at production methods and which resources that goes into the production. I also think a lot about transport and of course how we dispose the remainders of the food and the packaging"* (P3).

While assessing whether a food item is sustainable was a process that included a variety of different factors (see section 4.3 for further explanation), the current data and/or information landscape was not deemed sufficient by the participants. This was unfolded by P16 in the second interview, where she noted that the shopping probe exercise was difficult for her. She said that: *"I think I ended up having a lot of yellow labels"* (P16), which also can be seen in one

Fig. 3. An image taken by P16 that shows an overview of the items that she bought, where the majority have been labelled with a yellow sticker.

of the images that she took during the probe exercise (see figure 3). The yellow labels reflected her doubt in relation to the items. She elaborated in writing during the exercise (see figure 4) that she in general could not see where the items were produced and by whom. Moreover, for her, what it meant for the environmental impact that the items were wrapped in plastic or put in a glass or a can.

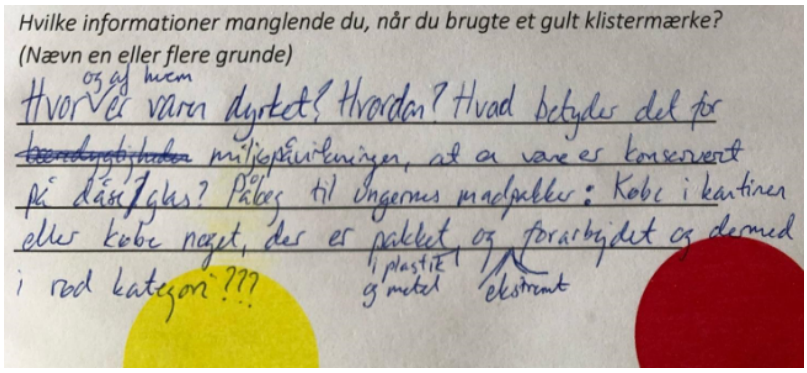

Fig. 4. The figure is a snippet of one of the reflection questions from the shopping probe exercise and the answer that was given. The question states: "When using a yellow sticker, which kind of information did you lack (Choose one or more reasons)". The answer: "Where and by whom the items were produced? What impact does it have on the environment that the item is contained in can/glass. Cold cuts for the kids' lunch: Buy in the canteen or buy something that is packed in plastic and extremely processed and therefore in red category.

Food labels played a big role in the participants' grocery shopping practices. However, the participants also vocalized various shortcomings with food labels: *There are a lot of food labels that concern health and nutrition etc., but there is not really anything for sustainability. [...] There could be more information on the packaging about CO2 footprint and water usage in production because right now those aspects very much lack transparency* (P5). As it was described by P5, the current landscape of food labels was perceived to focus mainly on health and nutrition, where she demanded a more extensive focus on sustainability. This view was shared by the majority of the participants (N=14). P6 explained a need for a label that considers international guidances: *"I think it would be great if there was some kind of label with a scale on it that considers the CO2 footprint and the climate. [...] Just like they have made the keyhole label in EU that concerns what is healthy for us* (P6). Similarly, P8 noted that a sustainability label should be based on the UN sustainable development goals: *It could be good with a label that... Just like with the UN goals it would have like five parameters in different colors and then with pillars you should be able to see animal welfare in one and CO2 in another [...]* (P8). There were various different ideas concerning how sustainable food data could be interfaced with through labelling. However, P12 expressed that it should not just be one more label among all the others: *"The problem now is that there are so many labels. It is a labelling jungle right now. There should instead be an EU label that shows the CO2 footprint for transport, packaging, the whole supply chain and the production."* (P12). Besides the concern of the fact that there is a large number of food labels out there each covering a part of the whole, P14 expressed another concern in relation to a sustainability label, namely that seasons change the footprint of the food items: *"How can one make a CO2 label for danish tomatoes if their footprint in the summer is very low and in the winter very high. [...] Then it has to be calculated every month, right?"* (P14). The above identified a need for more sustainability-oriented food labelling, seeing as of now most labels focus on health and nutrition. However, there were also seen multiple pitfalls in relation to sustainability labels that would have to be accommodated for, in order for them to be meaningful for the sustainability-conscious individuals.

4.3 Meaningful Data for Practicing Sustainable Food

It became clear that the current information regarding sustainability of food was lacking transparency in relation to provenance. This section examines more specifically, which kinds of data that are meaningful for the participants in order to act in a sustainable way.

4.3.1 Food Production. For all participants, having insight into the production of each food product was important because it alludes the environmental impacts of the processing of the product: *"I look for where it [the food] is produced and who produced it. Also, whether or not it is organic"* (P1). Although, it is not always easy to grasp the real impacts: *"[...] I cannot grasp what impact processing really has on the climate footprint"* (P4). Regarding the production of food items, climate footprint, organic production, water usage, welfare, and packaging were especially meaningful for our participants. P8 hoped to know about water usage in production to assess the sustainability of an item: *"I know that there are used extreme amounts of water to produce almonds and therefore I avoid them. [...] Maybe I am fanatic, but If I could see water usage in production that would be useful"* (P8).

4.3.2 Supply Chains and Local Food. Also in relation to supply chains, meaningful data was not visible. P16 stated that: *"Then you can see the country of origin, you know which country the item is from. The thing you cannot see is how many times it has been to different countries in order to be processed and sold"* (P16). Our participants were often frustrated about the fact that they had to search and examine such information through the given food labels: *"[...] backtracking soybean products from Denmark, well that is almost impossible. Maybe it is also a Utopian thing to wish for"* (P5). It was a general concern that the participants did not know how far the product had travelled and with which type of

transport, as P12 noted: *"Although transport might be a small part of a products' climate footprint, it is still important for me to understand whether something has been flown or driven here"* (P12). Furthermore, P1 exemplified this concern by looking at strawberries during off season: *"Strawberries frown in from Australia and what not are certainty expensive on the sustainability account"* (P1). The quote from P1 also touch upon another important aspect of sustainable food consumption, being that of seasons and local food. P3 also noted that *"If I was to buy something that is not in season then I would begin to wonder how it was then produced."* (P3). By questioning the data that she was presented with, in this case what type of food it was and where it was produced, P3 was able to derive whether the food item was produced in a natural or an artificial way. Eating plant-based was another aspect of sustainable food that all the participants agreed upon was the right choice. Combined with only eating plant-based food, P8 strove to buy locally produced food so that she did not have to deal with extended supply chains. However, it is not as simple as cutting the animal products from the dietary. P10 brought up this complexity by comparing an animal product with tomatoes off season: *"I do not eat a lot of fresh tomatoes in the winter. Although they taste good, they are as bad for the climate as beef [...] if you calculate per calories and per protein that you get and so on"*.

4.3.3 Organic food. For our participants, organic food was an prominent aspect in their sustainable food practice. For example, P9 insists to check for organic labels: *"I always look for whether or not it [the food item] is organic. Whether it says organic or has an organic label"* (P9). To the participants, organically produced meant that the product was not produced in a heated greenhouse, which they agreed was a bad thing: *"There is a problem if they [the vegetables] are produced in a heated greenhouse compared to if they are grown on a field somewhere here"* (P3). Although the participants all looked for organic products, they stated that the meaning of the organic label differs between countries, which sometimes complicated things for them. P11 explained this as follows: *"Then the product has a label that says organic and then it says the Netherlands. But there are different standards for what is called organic in different countries. For example in Denmark the standards for organic food are very high"* (P11). Although the participants did not have a clear understanding of what the organic label entailed, they still used it on a daily basis to guide their purchases.

4.4 Experiences with Existing Sustainability Technology

Technology played an extensive role in the participants' engagement with sustainable food data. This section concerns the existing technologies that sustainability-conscious individuals engage with during their practice of sustainable food. We also present alternative digital interfaces that our participants suggested for future interactions with sustainable food data.

To some extent, four of our participants also used carbon footprint calculators. However, multiple challenges with using them were identified, as P14 stated in the following: *"I am missing a little bit of the... What is it that makes it react? I get a total saying that I have been 30 percent worse than last week. But it does not say why?!"* (P14). Providing the participant with only the resulting climate footprint left her with unanswered questions regarding which products were problematic seen from a sustainability point of view and which were not. For example, P2 often received unexpected results from the calculator: *"An example was that I bought a ready-made pizza dough which the app said had a very big climate footprint and that made me wonder, since it categorized it as a ready-made dish. [...] I could not see why it had a big footprint"* (P2). Her confusion made her try to look closer into the data, but she was not able to do so. This is a part of the experiences that our participants had regarding the lacking transparency in the food data. P16 expressed that the current state of the technology did not match her shopping practice given that the calculator was only able to calculate items from one specific chain store, which couldn't reflect her grocery shopping in multiple stores. As of now,

food specific carbon footprint calculators most often provided the individual with a simplified result based on the data input. P10 described his take on the uncertainties of sustainable food calculations as follows: *"You can only lean against some standard values and then hope that everything is produced in somewhat the same way, but it is uncertain, since you do not know what you get in the store"* (P10). He problematized the invisibility of the current algorithms embedded in the calculator, such as which data inputs were chosen and how much each input was weighted. Some participants (P1, P10, P14) also criticized CO2 as a measurement unit, suggesting alternative ones: *"It has to be CO2 pr. something so that you can compare with other things and I think that CO2 pr. nutritional content is probably the way to do it"* (P10) and *"CO2 pr. calorie intake... that could be a good indicator"* (P14). Generally, there was identified a skepticism amongst the participants regarding missing transparency in the calculations and in the available technologies.

To deal with the current data invisibility and lack of transparency, our participants suggested redesigning the current form of digital interface somewhat radically (P3, P5, P9, P16). For example, P9 would like more storytelling in the form of both textual descriptions of where the food was produced and transported and imagery of the farm where the food was grown: *"Then you should be able to scan and then a screen would tell you a story about the product, like a picture of where it was produced and information about which country and all that stuff."* (P9). Additionally, P16 noted that she would like an overview of the individual items, displaying whether it was in season, its supply chain, and the climate footprint of the item: *"I imagine something that could tell me if the product that I wanted to buy is in season. Having an app or something would give me a quick overview of that"* (P16). The early stage of the technological development for sustainable food in this context was shown to raise challenges for the sustainability-conscious individuals. However, opportunities were identified both in redesigning sustainability labels and digital technologies for supporting the individuals in acting in a sustainable way.

5 DISCUSSION

In this section, drawing upon Loukissas' six principles [60] on thinking critically about data, we first provide insights about meaningful data for sustainable food practices. In table 2, we present each principle together with a small description of it and our insights about meaningful data for sustainable food practices. Furthermore, we propose possible design directions for sustainable HCI technologies utilizing with food data.

5.1 Insights about Meaningful Data for Sustainable Food Practices

In the dissection of the term "local" in his first principle of "all data are local", Loukissas explains that the notion of local forms our relationships with data and the conditions under which the data are created [60]. As a way of obtaining this relationship with data, he proposed being able to look "into" data instead of "through" data - to see how they are collected, managed and displayed instead of merely using them as autonomous objects of knowledge [60]. Loukissas points out that data have been perceived as universal and invariable [60], echoing other data studies that have shown that data change meaning from one context to another [27, 38]. Alternatively, he draws our attention to the **locality** of data: the socio-technical conditions under which data are created provide them with meaning about their locality [60]. In food data context, locality could be climate, means of productions, regulations around the production, etc. For example, locality of food reveals the intersections of the location where the food was grown and meaningful information about seasons, transportation, and whether the food is organic. If food is produced locally without being in season, the sustainability-conscious individuals expect it to be produced artificially (e.g., greenhouses made from aluminum and fueled with artificial heat). The notion of local uncovers aspects of the food that would not be obtainable if food data were treated as **universal**, such as means of productions in different countries and the transport of the specific food

item. While these are aspects of food that impact the degree to which they are sustainable, current food data often discard the socio-technical contexts that shape them (cf. table 2, first principle). For example, a locally grown tomato and a tomato from the opposite side of the planet are treated as the same tomato in carbon footprint calculation. The locality of food needs to be present, as it is not possible to understand local in relation to an imagined universality [36].

Another core concept from Loukissas, is that of **place**, similar to locality but referring to the situated and embodied aspects that provide meaning to data [60]. For example, place of food data relates to how the data gathered from the specific farm impacts the data and how traces of place are incorporated in the data. In section 4.3, we identified various parameters of place that provided our participants with insight into the sustainability of food. Our participants looked for organic food, climate footprint, water usage in production, travel miles, and type of transportation. For them, data about water usage not only help identify different kinds of foods (e.g., rice needs large amounts of water) and the average temperatures of the harvesting places. Coupled with the region from which the food origins, they also gain insight into whether water poses a conflict for the public, which is the case in multiple areas of the world [76]. The absence of traces to place of food (provenance) invisibly structures how our participants could engage in interpretations of the food data [60]. To deal with this issue, visualizations have been a major approach to incorporating comprehensive aspects of sustainability, in both fields of sustainability labelling [31, 54] and of digital technology for sustainability [21, 45, 49]. Among others, Galvez and colleagues [31] discuss the possibility of using block chain technology for improved traceability of food provenance, however block chain technology also poses new challenges in relation to authentication (e.g., evidence of provenance) and tracking (e.g., sensor quality). As Loukissas argues, visualizing places generate alternative experiences of the data and the places that they depict [60]. Visualizing place of data could be made possible through the kind of storytelling that especially one participant requested (cf.4.4).

Interfaces recontextualize data by taking data out of the context in which they are made and then creating a new context them (cf. table 2, fifth principle). Loukissas uses the term **operational context** to describe what meaningful data interactions would look like: "[...] an operational context for data is a culturally defined setting in which participants are equipped with the resources and subject roles necessary to access, interpret, and take action on predetermined objects of attention." [60]. To describe the operational context of an interface, he borrows an example from Clifford Geertz about eyelid contractions. Merely having the data that three boys have contracted their eyelids does not tell the observer anything about the motivations for doing so. Only by identifying the context is the observer able to extract meaning out of the data, in this case, that one contraction represented a twitch with the eye, the other a wink, and the last a parody of a wink [60]. In sustainable food, having insights into the specific production processes, supply chains, governmental regulations etc. would for example provide an operational context for assessing whether or not food can be deemed as sustainable. Interfaces for sustainable food (e.g., CO2 indexes and carbon footprint calculations) have often displayed sustainability as simple (e.g., kilos of CO2) [67], which challenged our participants when wanting to buy sustainable food products based on their sustainable knowledge. To support existing sustainable practices, the design of interfaces should incorporate these practices (e.g., extensive searching for food data both at home and in-store, evaluating sustainability of a food item, online grocery shopping).

Our participants who used carbon footprint calculators in their sustainable food practice were frustrated about the fact that they were not able to look more closely inside of this black box [52] of carbon footprints (cf. section 4.4). For example, it is enigmatic what elements of the product life cycle go into the calculation of carbon footprint. We suggest that design interventions provide ways to understand the "data artifacts" [60] —localized incidents that have the possibility to inform new readings of data— that are not apparent from the current output of a carbon footprint calculator. As an example of a data artifact, one participant shared the moment where she found that the ready-made

pizza dough was categorized as a ready-made dish together with other dishes that had different characteristics. This specific data incident developed her understanding of carbon footprint calculation as an imperfect process of quantifying food sustainability. In their assessment of classification systems, Bowker and Star argued that: *"The normally invisible quality of working infrastructure becomes visible when it breaks [...]"* [11]. Through breaking down the infrastructures that compose carbon footprint calculation, a richer understanding of carbon footprints could become visible. This finding can be coupled with the fourth principle of Loukissas (cf. table 2) that there is a need for looking beyond inputs and outputs when interacting with technology.

The participants used their **local knowledge** as a tool to bridge the gap between data from the current food labelling and the data needed to accurately measure the level of food sustainability. Such local knowledge is something our participants accumulated over the years of engagement in sustainable food (table 2, sixth principle). For example, with the food labelling found during grocery shopping, our participants had to use literacy about food seasons and provenance to figure out how much heat or water (e.g., through greenhouse in winter season) was needed for producing the food. Sustainable food data come from heterogenous sources, such as producers, retailers, interest groups, and governmental channels. Bringing data together from different sources revealed clashes in **data cultures**. For example, the participants viewed producers of animal products and producers of vegan products as two different cultures, both with their own interests for how much data they are willing to display. Different data cultures added complexity to those who practice sustainable food, since they hide or stress different aspects of food, such as nutrition, taste, or sustainability. This complexity needs to be respected as part of designing for sustainable food practices. An observation that was also made by Clear et al. [23] in their comparative study of sustainability-conscious shoppers and mainstream shoppers.

As we identified in the findings (cf. 4.1.2), there is a notable transition from food shopping in physical stores to online stores that might affect people's sustainable consumption practices [6, 41, 72]. For example, online food shopping makes it easier to practice sustainable consumption by providing better access to sustainable products, and more information about the products through a quick search [41]. While HCI research on sustainable food purchases has been centered around physical grocery stores (e.g., [21, 45, 49, 75]), online grocery shopping creates new opportunities and challenges by recontextualizing sustainable food data. Very limited work has been carried in the field of sustainable food shopping online. Lembcke et al. [56] investigated how a virtual shopping cart impacts sustainable grocery consumption. Their findings show that digital nudging in the form of real time feedback of the content of a shopping cart can impact shoppers to buy more sustainable [56]. From our study, we can point towards further implications of online food shopping. For example, how does tendencies in online food shopping convey with the participants' existing practices such as going dumpster diving? Also, how can we transfer the above insights and other findings from HCI research on sustainable food in physical grocery stores, to support sustainable online food shopping? We hope to provide nuanced understandings of this emerging context by locating sustainable online shopping communities in our future work.

5.2 Design with Food Data for Sustainable HCI Technology

In conclusion, we suggest three action items for studies utilizing food data in the design of sustainable technologies. The sustainable HCI and design communities have provided some insights on, for example, not assuming that all users are rational actors [71] and exceeding modernist tendencies (e.g., persuasive sustainability [13]). Building upon existing efforts, we propose several actionable items which would enable researchers to consider alternative methods and approaches for designing sustainable technologies with food data.

Principle	Description	Insights about Sustainable Food Data Practices
All data are local	Data are often seen as discrete, complete, and readily portable. This principle seeks to unfold the local conditions of data.	Sustainable food data are most often discarding the socio-technical contexts that shape them. Revealing locality in food data has the possibility to make food more transparent and data more meaningful for practitioners of sustainable food.
Data have complex attachments to place	Visualizing place, including social, technological, and spatial dimensions hereof, offers alternative experiences with data.	Absence of provenance invisibly structures how sustainability-conscious individuals can engage in interpretations of data as part of sustainable food practices. Alternative visualizations of provenance of sustainability can accommodate for the distinct ways of practicing sustainable food, where some focus on welfare, others on climate etc.
Data are collected from heterogeneous sources	This principle aims at uncovering the cultural attachments that are nested in data, as these help us understand traces of their origin.	Food data from multiple stakeholders show how different data cultures complicate sustainable food practices, since they hide or stress different aspects of food.
Data and algorithms are inextricably entangled	To understand what constitutes the data that we are presented with, there is a need to look beyond the beginning (input) and the end (output) of the algorithms.	The internal complexity of carbon footprint calculations is invisible. We suggest the possibility of embracing data incidents, rather than hiding them, in order to foster meaningful interactions with sustainable food data.
Interfaces recontextualize data	The interface layer impacts what data appear to communicate and it is therefore essential to think about this mediation between people and data.	There is a need to incorporate the existing practices into the design of interfaces and to generate alternative visualizations that incorporate the complexity of sustainable food practices. Additionally, tendencies in online food shopping changes the nature of data for practicing of sustainable food.
Data are indexes to local knowledge	Engaging with data is not only a question of extracting information, but a way of connecting with one's own knowledge and with the creators and users of the data.	Practices for sustainable food consumption are not merely practiced in the grocery store, but also before (e.g., searching what is local or not) and after (e.g., reflecting on the specific items bought). Practicing sustainable food entails a combination of available data and one's accumulated local knowledge.

Table 2. Overview of each of the six principles by Loukissas, together with a description of the core arguments of each principle, and our insights about meaningful data for practicing sustainable food.

5.2.1 Allowing Access to Comparative Perspectives on Data. Loukissas showed that by only searching with each of 'black' or 'white' as search words, we can discern how the database of the digital public library of America is heavily skewed towards Caucasian users (i.e., whiteness is not linked to any racial identity in the search results, while blackness is). As he found, the absence of racial perspectives in data resulted from work of white researchers, comparative analysis makes any hidden, often perverse, views visible. Conveying comparative perspectives on data could be one of our design interventions strategies by visualizing other localities of food data at one view and allowing them to filter out to access different aspects (e.g., production methods and transportation).

5.2.2 Developing Community Perspectives. Our study initially seeks how sustainability-conscious individuals deal with food data and what makes the data meaningful to them. However, we found that individuals' perceptions of food data did not rely solely on their values or decisions [17, 18]. They mostly gained local knowledge from their social circles and personal network (e.g., colleagues). Thus, their food consumption choices are not isolated and individual, but rather represent parts of their local communities' choices. Existing works (e.g., mobile apps) often utilize personalization by collecting customized information based on personal profiles or settings. While personalization might meet the direct needs of each user, it could obscure ongoing collective activities such as sharing local knowledge and learning from each other which affected our participants' perceptions of meaningful data. Technologies that facilitate the determination of community perspectives would allow us to develop actionable solutions in the community. For example, Aoki et al. [4] investigated how public awareness could materialize into environmental community actions which enable collected individual environmental data to exert a real impact on sustainability. While the authors talked with various stakeholders (e.g., governmental officers and NGOs) to get community perspectives, we see an opportunity for design interventions to develop community perspectives by connecting people with environmental agendas like sustainable food consumption.

5.2.3 Considering Political Views in Localities. Food data are "alleged evidence" in Buckland's terms [14]. We have shown that locality is also entangled with politics that shape people's degree of access to food data (i.e., there are no labels like "caged chicken") since it involves diverse stakeholders (e.g., the beef industry versus animal rights organization). How such politics affect food data availability, transparency and culture should be considered in designing with food data. Our participants were aware of the different "data cultures", for example, differences between the meat industry and plant-based products industry, and participants had their own stances on them. We also found that the same product's sustainability impacts could be accepted differently depending on political stances. How can food data represent these different views fairly? What visual methods could show the closeness between a certain food and different stakeholders? Furthermore, we suggest that technologies could provide a space where all stakeholders (e.g., government, domain experts, activists, consumers, etc.) could communicate, transfer, and negotiate over their different data cultures, functioning like what Galison calls *a trading zone* [30]. In this way, we enable different actors to be involved in creating data or adding nuance to the public understanding of food data; for example, local producers and retailers can highlight food regionality, their sustainable production processes and methods, transportation, etc., while governments and environmental experts can convey their reports directly to these active audiences. We should consider developing design interventions which ***can bring people together in examining, challenging and redefining the stories that data tell about food.*** Lastly, sustainable technologies should not be assumed to be only technologies for "consumers". As individuals have monitored their behaviors and been nudged by existing technologies, we as design researchers should go the beyond these individual-oriented solutions by working with governments, companies and expert groups, and activists [4] actively involved in creating, regulating, and advertising food data but have not been

considered as our conventional "users." To do so, we would need to reframe our question into not how individual consumption may affect environmental sustainability, but ***how individual consumption may connect to and engage with other stakeholders' interests*** [16].

6 REFLECTIONS ON THE DATA IN THE STUDY

The data in this study does not work with a clear cut definition of the term sustainability. This is because we strove to have the participants provide us with their understandings of the term without limiting them by our definition of it. When that is said, it is naive to think that our perception of sustainability is not influenced by external factors. For example, the use of the term sustainability in this study focused solely on the impacts on humans. However, scholars within the area of sustainability might call this an anthropocentric use of the term [39]. It can be seen as a limitation of the study that it does not take into account the impact on and of non-humans.

Our study was conducted in Denmark, which represents a technologically advanced and homogeneously populated country. Thus, our data fits well in addressing challenges and opportunities for people within this context. However in other countries, sustainable food related problems might relate to food security, water pollution among others. With our data, we found it is hard to address challenges of different socioeconomic and geographically distributed groups of people.

Lastly, our study has the gender imbalance of the participants (12 females/4 males). This imbalance might have been a result of our recruitment strategy. We mainly recruited participants from social media forums, however also asked participants to identify others that might be interested in participating. We did not aim to exclude participants, which is why we did not specifically aim to obtain a balance. During the study, we did not observe any noteworthy differences between genders in how they practiced sustainable food consumption.

7 CONCLUSION

Practicing sustainable food consumption has been gaining traction in recent years due to the fact that food is seen as a key sustainability issue and that it is becoming possible to collect and data in order to display various sustainability aspects of food consumption. In this study, we provide empirical findings of sustainability-conscious individuals' practices around food data. We identified that lacking data transparency, especially in relation to provenance of food, complicates practicing sustainable food consumption. By drawing upon Loukissas' critical data principles and concepts, we discuss how food data often are treated as universal by not being considered its socio-technical contexts. We call for rethinking the nature of food data and our practices around food data by considering the concepts of "locality" and "place," in order to design more meaningful sustainable food data interactions.

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