Really Smart Fridges: Investigating Sustainable Household Storage Practices

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***Abstract*—For a long time now, the 'smart fridge' is promised to improve everyday life in private households, supporting healthy eating habits and sustainable food practices. However, current technology is still not widespread and limited in its functions. Similarly, researched prototypes are rather persuasive and not aligned with consumers' storage practices. We took a practice theoretical lens to investigate current storage practices and actual refrigerators. As follows we present our work in progress and first insights from our contextual inquiry.**

***Index Terms*— Storage Practices, Smart Fridge, Human Food Interaction, Freshness, Shelf Life.**

I. Introduction

Consumers question their food consumption practices in order to contribute to environmental sustainability by trying to ensure food integrity, change their diet or the reduction of food waste. Despite good intentions and a large amount of available information, they are unable to make rational choices [2, 4]. Attempts to support the consumer through persuasive design do not achieve long-term impacts on sustainable behavior, but rather lead to characteristic breakdowns [3]. In contrast, practice theories have been used to uncover design opportunities [3]. Smart fridges and earlier ICT designs that were intended to support daily life are rather technology-driven [1] and focus on the opportunities for automation using new sensors [5, 6] and/or aim at the rational consumer [2, 4].

Therefore, we study food consumption as a social, routine practice and especially (re)storage as a link between food procurement, food preparation, and finally waste. Storage practices are often overlooked, although Ganglbauer et al. [6] emphasize their implications as crucial for understanding domestic food waste. To gain a holistic understanding of home storage practices, we conducted a contextual study of the storage space and refrigerator of 15 participants. As follows, we present initial findings and implications to design smart fridges.

II. Smart Fridges and Automation

Most research in Human Food Interaction focuses on production and eating; in contrast, only 3.5% of the overall publication is studying storing explicitly [1]. Likewise, Smart Fridge design research rarely incorporates storage practices. Other work is concerned with intelligent technologies to improve kitchen automation to make it as convenient as possible to trace the input and output of the refrigerator [5] and to create a reliable data set to search for stored products anytime, anywhere. Remote-controlled cameras and sophisticated sensor arrangements are implemented for this function [6]. However, due to the lack of machine-readable data generation and the narrow focus on awareness in procurement alone, market acceptance is limited. The sensor approach ranges from the use of RFID sensors to barcode or dimensional code scanners or weight sensors to a voice interface [5, 8]. The biggest limitation, however, is the lack of RFID tags on products, which is probably caused by the high costs and the difficulty of tagging unpackaged products. Overall, meaningful home automation still poses a challenge. Mennicken and Huang [7], for example, stress that automation is not smart if users do not recognize the benefits, can do the same task better or faster, or experience a general loss of control.

III. Contextual Inquiry of Household Practices

To investigate individual storage practices around the fridge, we conducted 15 semi-structured interviews with consumers from Germany and documented their fridge arrangements by taking photos. The sample varies in their sociodemographical characteristics like a profession or educational background, family status, dwelling and household, age, and gender. But all participants are mainly or partly responsible for household shopping and storage practices. The interview guideline covers topics on freshness, storage spaces, transport of purchased goods, examination and decision-making concerning food disposal and hygiene maintenance.

IV. Designing Really Smart Fridges

While none of our participants owns a digitally enhanced fridge, our practice-theoretical insights on storing show how the diversity of performances is not covered by current (smart) fridge designs. Therefore, it is not sufficient to simply add displays and features to make them ‘smart’. Instead, sensors should be implemented wisely to support storage skills and enhance food handling competencies for extended shelf life.

A. Support the assessment of freshness beyond shelf-life

Our study shows that attributes such as origin, regionality, short delivery routes, and sparse packaging are preferred indicators of freshness and sustainable food choices. The performance for assessing freshness changes between procurement and storage, but the objective of preserving the longest lasting shelf life remains the same. We observe participants rather performing complex procedures to check food freshness. Thus, they try to recall opening dates of packages or certain characteristics like the 'smeariness' of meat or the 'crumbliness' of sour milk. As health risks increase, participants become even more cautious. Young people, in particular, are dependent on the knowledge from their upbringing home and do not always have efficient skills to maintain freshness and hygiene. While within families or partnership responsibilities for hygiene are more clearly assigned, in shared flats cleaning is often neglected or some participants only clean parts of their compartments.

To support the decision-making process at the moment, smart speakers positioned in the kitchen might guide to assess specific characteristics of doubtful food quality. Information at hand fosters trust in the user her- or himself with his or her skills and knowledge. By sensing the degree of filth in the fridge, the assistant might set reminders for cleaning autonomously.

B. Teaching storage-related competence

There is great uncertainty about the placement of food in the fridge as well as outside, and which products to place next to each other. We reveal that people 'negotiate' storage with the hardware design of the fridge and its various shelves and boxes, with each section of the fridge 'communicating' its purpose, as one participant explains. Pre-installed carriers invite the user to store eggs in a refrigerated environment, even if this is not immediately necessary. Storage rules are often violated for convenience. Conflicts arise, for instance, if inhabitants are not willing to store their food in the 'right' temperature allocation, but assign drawers and shelves for individual purposes. As for flat inhabitants, the separation of food, to generate a shared and clear understanding of ownership, is preferred over optimization of shelf life. In the case of families and partnerships, we typically observe one person mainly responsible for storage maintenance. They have often to restore products, as other residents randomly place food. In some cases, sophisticated storage plans are implemented based on storing purchased foods after their expiration date by placing older and open items more visible at the front of a shelf and newer ones at the back.

Since color-coding fridge compartments [4] has already shown some short-term effect, long-term, implemented LED lights might guide to store food right and adapt to the number of inhabitants or stored products. Likewise, the fridge could provide wider support for understanding and actions on existing normativity by showing the best storing place.

While Ganglbauer et al. [6] cite visibility as the reason for repackaging, none of our participants reported that visibility was improved by the use of containers. This could be due to the fact that the containers are often made of opaque plastic and thus hide the remaining quantity. A common reason for repackaging that we have found is, that once the product is opened for the first time, it cannot be sealed. Similar to Ganglbauer et al. [6], however, we also observe aesthetic motives for repackaging to make the food look "appetizing". Moreover, the use of own packaging is ecologically motivated. Some participants try to reduce waste caused by their food packaging and therefore buy unpackaged goods. By rethinking the fridge as a modular system, a range of 'smart' RFID equipped containers could enhance visibility, aesthetics and more real-time information on best before dates.

V. Conclusion

In contrast to previous research that either focuses on the enhancement of the smart fridge sensing capabilities [5, 8] or the motivation of users, employing persuasive design [2, 4], we focus to uncover everyday routines rather than attempting to persuade users of sustainability and health considerations. Although participants explained they know certain rules of 'how to use the fridge', trade-offs between personal goals, such as visibility, ownership, and space limitations are inevitable. Similarly, we observed food-related competences varying from very explicit routines and knowledge to high uncertainty and laissez-faire handling.

VI. Poster presentation

We would like to present our findings with quotes and pictures of the participants' fridges to discuss possible design implications that would make the fridge genuinely smart, like a modular design or guiding lighting cues. With an interactive paper game, we would like to design really smart fridges with the participants of the ICT4S conference.

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