Nutriflect: Reflecting Collective Shopping Behavior and Nutrition

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ABSTRACT
A poor nutritional state, as is the case for many people today, can increase risks for cancer, cardiovascular disease and obesity. Technology supported approaches could potentially be used to positively influence food consumption. We present the Nutriflect system, which utilizes users' shopping data to inform them about their long term shopping behavior. In an initial study we conducted structured interviews in grocery stores. Based on the results we implemented a system that visualized a household's collective shopping information via situated displays. The aim was to raise awareness about shopping habits and to enable reflection about nutrition without burdening the users with the manual entry of their eating habits. We evaluated the system in a 4 week field study in 8 households with 21 users. The results indicate that contextually situated displays, showing shopping patterns against personal nutrition goals, can foster a reflective and respectful approach towards better shopping and nutrition.

Author Keywords
Nutrition; shopping; awareness; behavior change; reflection; situated displays; field study

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
In Austria as well as across the European Union, people's food consumption and nutrition still leaves considerable room for improvement [2, 9]. On average we still eat too much fat and salt, and too little fruit and vegetables [9]. Nutrition has been associated with a number of health issues, e.g., the regular consumption of fruit has been linked with a lower risk of asthma in children [8], whereas unhealthy diets are seen as one of the major risk factors (besides physical inactivity) for cardiovascular disease and cancer by the WHO [3]. Furthermore, obesity is another pressing nutrition and health related issue, with 34% of adults being overweight globally (body mass index > 25) [18], and one fifth of the population either overweight or obese in Austria [9]. This provides an opportunity for HCI to design technology-enabled solutions in support of good nutritional choices but the challenge is to do so in a way that respects the autonomy and unique contexts of people, and to provide support without undue effort on their part.

CHI 2014, April 26 - May 01 2014, Toronto, ON, Canada

ACM 978-1-4503-2473-1/14/04…$15.00.
http://dx.doi.org/10.1145/2556288.2557384

The Nutriflect system presented in this paper addresses this challenge and aims to empower people to make use of their own grocery shopping data as a source of awareness about their household's consumption patterns[1]. By providing the possibility of continuous reflection about nutrition through situated displays, it potentially nudges users towards healthier shopping behaviors.

This paper starts with a presentation of related work and continues with a description of an initial exploratory study in the domain of food shopping. After this our Nutriflect approach is presented, followed by a description of the actual prototype used in the field study. Subsequently, the study setup is introduced and the results are outlined. This is complemented by a discussion and some concluding remarks. The main contribution of this paper, arising from the exploratory study and the field study with a deployed prototype, is showing that contextually situated displays can foster a reflective and respectful approach towards behavior change regarding shopping behavior and nutrition. The Nutriflect system serves as a research vehicle to explore ubiquitous computing technologies that provide feedback about food consumption patterns.

RELATED WORK
In this section we present an overview of related work in the areas of ubiquitous computing and situated displays as enabling technologies for Nutriflect. Furthermore we look into the area of behavior change and persuasive technology, in which this research is theoretically grounded. We end

[1] In this paper, *consumption patterns* refers to the groceries bought over time and not to the actual act of consuming, i.e. eating the food.

with a brief overview of related current approaches in HCI regarding food and nutrition related issues.

Ubiquitous computing and situated displays

The utilization of ubicomp technology for influencing behavior enables the presentation of persuasive cues in a contextually adequate way [31], raising the potential for successful behavior change by utilizing the principle of *kairos*, which states that "a computing technology will have greater persuasive power if it offers suggestions at opportune moments." [11]. While there are several potential opportunities where consumption decisions take place, e.g., while shopping in a supermarket etc., in this paper we focus on people's homes as a place for continuous reflection on their household's consumption, and not so much on providing immediate in-store feedback.

The home context has also been subject to numerous behavior change interventions, mostly in the area of sustainable energy consumption. Systems in this area typically consist of a situated display that gives feedback about electricity [17] [19], or water consumption [10] with the goal of raising users' awareness about their related behaviors and ultimately influencing them towards a reduction in energy use. The input for the system is derived automatically based on people's consumption patterns.

However, in the area of food and nutrition the input is usually performed manually by the users [32, 34]. As this can be time consuming and burdensome for the people who utilize such systems in the long term, Andrew et al. propose the use of a simplified mobile food diary [4]. There are also approaches to make food logging easier, based on the use of mobile photography [20], and Noronha et al. use crowdsourcing to analyze nutrition information about photographed meals [25]. Furthermore, Pässler et al. propose the utilization of wearable sensors for food intake recognition [28]. The Nutriflect system explores a different novel approach to generate awareness about nutrition without burdening the user with manual data entry by using existing grocery shopping data to provide feedback about food consumption patterns.

Behavior change and persuasion

The use of computers to change peoples attitudes and/or behaviors has been denoted as persuasive technology by Fogg [11]. He states several principles that can be used to facilitate behavior change, among them recognition, self-monitoring and social facilitation. Based on Fogg's work, Oinas-Kukkonen et al. [26] developed the concept of behavior change support systems that informs the design of systems and applications in this area. According to Fogg [12], the principle of social facilitation, which refers to technology allowing user to compare themselves and their behaviors, is one of the most powerful persuasion strategies. Yet, the excessive and unelected use of strong persuasive mechanisms in interactive systems has been the subject of critical discussion within HCI [29, 30]. Taking this critique seriously, the Nutriflect does not follow a strict persuasion paradigm but rather provides resources and opportunities for awareness and reflection, aiming to empower users to make more informed choices. Nutriflect also respects the users privacy and does not force social competition on them by sharing their data via social media but rather aims to engage them in a collective dialogue about their nutrition.

Our work is also informed by research in the area of behavioral economics and in particular by the concept of nudging, where people's free choice is preserved while they are provided with a choice architecture to enable them to make better decisions [33]. Key strategies in this domain are the default option strategy, the planning strategy, and the asymmetric choice strategy, which have been applied already in HCI by Lee et al. [21]. For our prototype design we employed the default option strategy by using the settings of the food pyramid, which is a beneficial and healthy choice for most users, as default setting in which the shopping behavior was framed.

Food and Nutrition

There is also a growing body of HCI research on how to use ICTs to promote healthy nutrition. Grimes et al. [16] present a game, which is based on the Transtheoretical Model. It is targeted at adults and aims at fostering healthful eating. Mankoff et al. [24] describe a system based on optical character recognition of shopping receipts, which offers healthier alternatives based on the previous purchase. The approach of collecting the shopping data by using receipts is also part of the Nutriflect System. As outlined in their future work, Nutriflect explores the use of ambient displays to give feedback. Whereas the Mankoff et al. [24] system provides users with particular healthy alternatives, Nutriflect enables reflection about health aspects of nutrition but leaves the decision about which specific foods to buy with the users. As Maitland et al. [22] suggest, system designers should not force behaviors onto users but rather help them make their personal changes. They also propose that systems should enable realistic goals, which Nutriflect supports through its configurability.

Mamykina et al. showed in a study that collaborative tagging of food pictures enhances the ability of individuals to remember the meals [23]. This underlines the importance of social aspects of nutrition, as stated also by Comber et al. Food consumption and preparation are complex and situated within the broader social practices of a household [6]. While Grimes et al. [15] focus on the community level in systems for nutritional change, Nutriflect emphasizes the household as context for food practices, where social interaction is not only mediated but takes place face to face. Ganglbauer et al. point out the significance of visibility for everyday food practices in the household, in particular food waste [13]. In Nutriflect, we build upon these findings and employ the principle of visibility to shed a light on a household's food shopping practices. We acknowledge the social nature of food related practices by focusing not on individuals but rather on the entire household as a collective and complex entity.

EXPLORATORY STUDY

To get a sense of the technology use and the attitude of people towards new ICT based approaches in shopping, we conducted 125 structured in-situ interviews with shoppers in different retail stores in the Vienna metropolitan area, including shops from the major national supermarket chains. The interviews were documented on paper forms by the researchers. In particular we were interested in the topics of CO2 footprint, healthy nutrition and costs/pricing information. The interviews focused on whether these topics were in fact interesting and relevant for shoppers and whether they would like to use a potential system in these areas. The questions were coded according to our research themes and subsequently analyzed descriptively using a pragmatic taxonomy developed for this study. Conducting the interviews in actual shops lead to a heterogeneous sample of people already in an everyday shopping routine. The participants' average age was 37 (SD=14; Min=14; Max=75), 54% were female, 39% with bachelor degree or higher. We asked about general technology and usage, smartphone usage, Near Field Communication (NFC) awareness (as an example of a fairly new technology), and interest in in-situ and long-term information of purchased products.

Analysis of the data showed that 88% of the participants use a PC on a regular basis (2-3 times a week), 30% a DVD-player, 37% a MP3-player, 100% a mobile phone, 16% a tablet PC and 56% a stereo. 71% of the participants have already shopped over the Internet. 64% own a smartphone, but only 29% of them had already heard of NFC. Another 10% of those have already used it. Regarding shopping behavior, 52% of the participants, who almost always or often care about the carbon footprint of products they buy, would appreciate support through PC or mobile phone. Moreover, 45% of those who just sometimes, seldom or never care about the carbon footprint would more likely care about it when having support through PC or mobile phone. 48% were interested in a long-term overview of their purchased products, 80% of them strongly agreed or agreed to a long-term overview regarding carbon footprint, and 80% were interested in health and nutritional aspects and 83% in costs (see Figure 1). This shows that, just like the topic of sustainable shopping, healthy nutrition and a technologically supported long-term overview of purchased products are very promising areas in which to focus further research efforts.

IMPLICATIONS

These results serve as a first indication that an ICT based approach would enable us to reach a large portion of average shoppers, as indicated by the high percentages of participants who use PCs, mobile phones and other devices

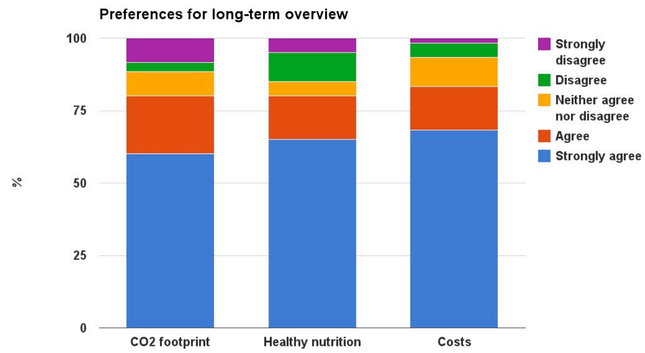

Figure 1. Preferences for long-term overview

regularly. Using a smartphone and shopping over the internet are not the exclusive domain of particularly tech-savvy sub-groups anymore, and systems designed to reach the average shopper can thus build on these experiences without excluding large user populations. The key finding of the exploratory study was that roughly half (48%) of the participants were interested in a technologically supported long-term overview of purchased products. Thus, we looked further into the promising areas of sustainable shopping (CO2 footprint) and healthy nutrition. We discovered that while data about the CO2 footprint of selected products is available, there is a lack of reliable information about the CO2 footprint for a considerable number of products included in everyday grocery shopping (cf. [14]). Therefore it would be difficult to provide accurate and comprehensive feedback to the users based on their actual real world consumption patterns. We thus decided to focus on nutrition, where data for a large number of products is available and where we could develop a prototype that enables a long-term overview of shopping behavior with a particular focus on nutritional aspects.

NUTRIFLECT APPROACH

With Nutriflect, we want to address an important sociopolitical challenge that faces many developed countries. According to the Austrian nutrition report 2012 [9], a major part of the population eats too much fat and too much salt and too few fruits and vegetables. This is confirmed by the fact, that one in five Austrians is deemed to be obese. Nutriflect provides users the possibility to continuously reflect on their consumption patterns. To keep the additional effort for users to a minimum and reduce the need for manually recording nutrition behavior, the consumption data should come from existing sources. Currently, customers more or less voluntarily leave their data to the shopping retail chains where they buy their products. A large number of companies use data analytics for personalized and highly tailored advertising [7]. Nutriflect aims at developing possibilities that also enable the customers themselves to benefit from the collected data. Therefore, we propose to make use of these data to provide a long-term overview of a household's shopping habits in terms of their nutritional composition. Thus, the purchased

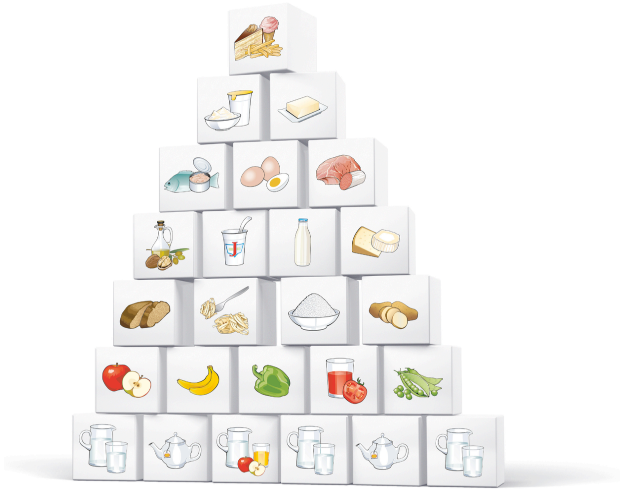

Figure 2. The Austrian food pyramid (by Österreichisches Bundesministerium für Gesundheit [Austrian Ministry for Health]) [27]

products are analyzed and classified according to the current Austrian food pyramid (see Figure 2)

The categories of this food pyramid are as follows [1]:

- Fatty food, sweets and savory products: Food with high amounts of fat, sugar and salt. Sweets, pastries, fast food, snacks, lemonades.
- Fats and oils: High quality vegetable oils as olive oil, rapeseed oil, other oils (walnut, soya, linseed, corn, sunflower, pumpkin seed and grape seed), nuts, seeds, butter, margarine, whipped cream, sour cream.
- Fish, meat, sausage and eggs: sea fish with high fat content or domestic cold water fish, low-fat meat, low-fat sausage products, red meat, eggs.
- Milk and milk products: milk, yoghurt, curd cheese, cottage cheese, cheese.
- Cereals and potatoes: cereals, bread, pasta, rice, potatoes, bread/whole-grain bread, pastries, bread rolls.
- Vegetable, pulses and fruits: cooked vegetables, raw fruit and vegetables, salad, pulses, fruit, fruit juice.
- Non-alcoholic beverages: water, mineral water, unsweetened fruit or herbal teas, watered down fruit and vegetable juice.

We use these categories to group the shopping data of the users according to the recommendations of the food pyramid. To make the products comparable, we used the calorific value (Kcal/100g or Kcal/100ml). To ensure a clear understanding for the user, the processed shopping data is presented as a graphical visualization that can be accessed via a situated display, for example in the user's kitchen. Through the constant awareness of the food composition, the hope is that users can continuously reflect on their purchases and are motivated to adapt them to reach the goals of the food pyramid. Households are also able to set their own goals as an alternative to the defaults of the food pyramid to adapt the system according to their specific needs and preferences. To gather the relevant data about purchased products, we propose a cloud-based system, where billing data can be synchronized during the payment process. In the next section we present the Nutriflect prototype which is used to explore this approach. The prototype encompasses the key elements of our approach except the fully automated data retrieval, which is approximated via wizard of oz.

PROTOTYPE

Based on the Nutriflect approach, we iteratively developed an interactive prototype to evaluate our approach. The prototype served as the basis for our study, conducted in realistic settings in several households. To reach highest possible compatibility with a variety of devices and platforms, we chose to base our implementation on a web service. This allowed us the usage of different devices to display the graphical feedback of Nutriflect. Furthermore, we were able to keep track of the process of the study (once the system was deployed) at all times by logging in to the web service. The backend of the web service was implemented on a server located at our University, using PHP and a MySQL database. For the user frontend we used different types of tablet PCs, 5 Nexus 10, 2 iPads and 1 Galaxy Tab. As we implemented the user interface as a web service, Internet access was required for the devices. Therefore, we provided mobile broadband SIM-cards for participating households without Internet access.

For the visualization of the nutrition data, we needed to store all the products bought by the participants, including the EAN-code as primary identification number, the name of the product, the number of calories per 100g or 100ml and the appropriate food pyramid category. As none of the major retail companies agreed to provide the shopping data of their customers, we had to enter all the products including the details by hand. Through this wizard of oz approach we could almost keep with the desired principle of no manual entry for users, who only had to submit their shopping receipts. Although not very scalable, this was adequate for our initial study to explore proof of concept. The manual data collection led to a minor delay between the time of shopping and the entry of the receipt into the Nutriflect system. However, we tried to minimize this delay by distributing the necessary data entry of the receipts between the members of the research team, which was augmented with an additional person for this task.

The data entry was quite challenging, as the receipts only showed the name and the price of the product and not all the retailers provide the necessary product information (see above) online. For some receipts we even had to check the calories and the package size directly in the store. To support this, we designed an easy-to-use web interface for

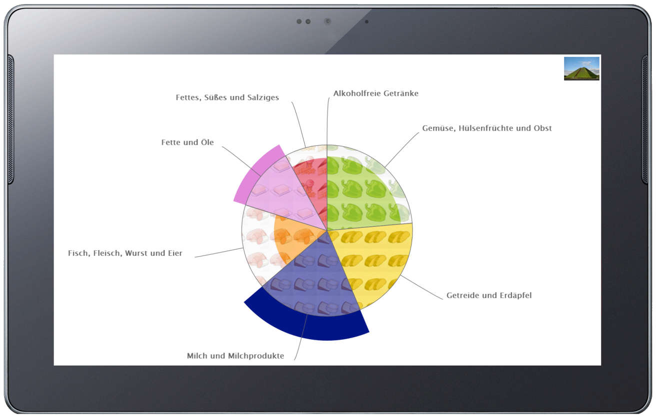

Figure 3. Nutrition Circle visualization showing a comparison between goals and actual consumption

Figure 4. Rising Smiley visualization indicating the overall status of a household regarding its goals

both building up the product database as well as entering the user receipts. To support the workflow of the food data entry, we connected our Nutriflect system with an existing food database called "FDDB". Through a developer API provided by "fddb.info" we were able to automatically retrieve the necessary product information, at least for a large number of products. After all products of a receipt were entered, the Nutriflect system calculated a delta value indicating the difference between the optimal ratios of food types based on the food pyramid and the actual ratios for the household. This delta value was the basis of the two information modes provided for the users in the households.

Information Modes

We provided two different types of visualization for the Nutriflect user interface. The first visualization showed the analysis of the shopping data in an adapted pie chart, which we called the "Nutrition Circle"; the second represented a more ambient approach to visualize the data.

Nutrition Circle

The Nutrition Circle showed the delta between the optimal food composition according to the food pyramid and the actual shopping data of the household (see Figure 3). It was implemented as an overlay of multiple interactive JavaScript charts, using the highcharts.com API. The Nutrition Circle consisted of a basic pie chart, showing the optimal composition. Each sector represented a category of the food pyramid, which was illustrated through a colored and slightly opaque background image. The actual ratios for the purchased food were shown as overlays on the sectors of the basic chart. These overlays used a more saturated color to be clearly silhouetted against the ground circle.

Additionally, each sector had a textual description. Each sector of the Nutrition Circle showed the difference between the recommendation of the food pyramid for the particular category and the actually purchased products by the distance between the arc of the basic sector and the arc of the overlay. If the purchased products met the recommendations, the overlay exactly filled the basic sector. To change to the other visualization, a button was placed in the top right corner of the screen, showing a small preview of the next screen.

Rising Smiley

The second ambient visualization showed a smiley icon climbing a pyramid (see Figure 4). The position of the smiley was determined by the overall delta value between optimal food composition according to the food pyramid and the actual shopping behavior. If the delta was very high, the smiley had to stay on the very bottom of the pyramid. If the shopping behavior met the recommendations very well, the smiley reached the top of the pyramid. Thus, the positioning of the smiley mapped the summed up distances between the arcs of the basic pie and those of the overlays in the Nutrition Circle view.

However, the Rising Smiley view had a very important additional type of feedback for the user: The mood of the Smiley indicates the impact of the last receipt of the particular household against the overall food composition. If the last receipt caused an improvement in the overall composition, the smiley was happy. If the last receipt had a negative impact, the smiley was sad. Twelve hours after the last receipt was stored in the Nutriflect system, the Smiley changed back to a neutral mood. This was implemented to provide the users immediate feedback, also for smaller changes in the delta value. Again, to change back to the other visualization, an image button was placed in the corner of the screen.

STUDY SETUP

To explore the use of the Nutriflect system in the wild and to assess potential behavior change effects, we conducted a 4 week situated field study in 8 households with a total of 21 inhabitants. Out of these, 4 younger children aged 7 or below were present in two of the households but did not actively participate in the study. The households were recruited from pre-study participants who indicated their interest in participation and via neighborhood and university announcements. They were not financially remunerated. The study participants were a diverse group, with ages ranging from 13 – 73 years and different migration backgrounds and technological skills, which should enable a multifaceted perspective on our prototype.

In the pre-study phase participants were asked to collect their shopping receipts for 2 weeks. These were entered in the system to provide a baseline for the respective households. The study started with an initial semi-structured interview, which included an introduction to the prototype. The researcher explained the different functions and helped the participants to customize the prototype according to their specific nutritional goals and needs, if these differed from the default settings that were based on the standard food pyramid guidelines. The displays were deployed in the kitchen (see Figure 3), where a suitable location for the displays was selected based on the preferences of the household members. The main considerations were visibility and reachability, and that the displays should not obstruct or interfere with any activities taking place in this space.

The participants were given a diary in the form of a calendar where they could enter whether they looked at the prototype on a particular day, if they had talked about it and any other observations or comments that they wanted to share. The prototype also logged any interaction with the system in order to get further insights into the interaction with the system over time. Furthermore, they were asked to keep any grocery receipts and scan them either with their smartphone or at home with their PCs and send them to the researchers for entering the shopping data into the system. With each new receipt we recorded the changes in the household's delta value, so we were able to analyze the progress of the consumption patterns over time.

At the end of the study, another semi-structured interview was conducted. The interview included questions about the usage and usefulness of the prototype as well as open-ended questions based on the diary and logging information. The interviews were audio recorded and the researchers took detailed notes, using the audio records to fill in missing details after interview. The data of the interview recordings, notes and from the diary were analyzed qualitatively to get an understanding of use of the prototype and to identify emerging themes. This was complemented with the quantitative data derived from logging the system usage and shopping behavior. As the interviews were conducted in German, the quotes were translated into English.

IDs of inhabitants	No. of inhabitants	Age and Gender
A1, A2	2	59(f), 73(m)
B1, B2	2	42(m), 39(f)
C1, C2	2	30(f), 32(m)
D1, D2	4	37(m), 35(f), + children
E1, E2	2	73(m), 63(f)
F1, F2, F3	5	37(f), 38(m), 12(f) +children
G1, G2, G3	3	47(f), 17(f), 9(m)
H1	1	29(f)

Table 1. Summary of households and participants in the study.

RESULTS

We collected a considerable amount of data from the above mentioned sources during our study. To feed the Nutriflect system with the necessary shopping data, we entered a total of 505 different products to our product database as well as 177 receipts consisting of a subset of one or more of these products. In the following we describe the various themes that emerged from the analysis of the collected data.

Situated Displays

The diaries and the corresponding log data show the continuous use of the system in all households throughout the time of the study. In the final interviews, users conveyed their observation that the Nutriflect display in their kitchen acted as a situated reminder of the system. In the words of D2,

"The display was in the kitchen, so I looked at it when I was doing food related things like cooking there. This was different from nutrition related smartphone apps I have used previously. I only used them a couple of times and then forgot about them as they were buried among all the other apps on my phone."

In a similar observation, E1 confirms the usefulness of a situated display:

"Having a display in the kitchen was clearly more convenient than a website, as it was there all the time and I did not need to do anything to see the information". For him, use of the system was also triggered after his grocery store trips:

"I had a look at the prototype at least once a day, in particular after I went shopping to see how it changed."

For F1 the central location of the displays served as a reminder; she stated that :

"I could hardly go to the refrigerator or cook something without having a look at the display."

Figure 3: Nutriflect Displays situated prominently in user's kitchens

Catalyzing Conversations

In the multi-person households, the Nutriflect prototype fostered conversations among the household members about food, grocery shopping and nutrition. Since the system did not display individual information about a single person's grocery shopping behavior but rather collective information based on the shopping data of the entire household, it was up to the members of the household to make sense of the results and understand their possible individual contributions and their implications for the entire household. As D2 stated:

"I thought we were doing pretty well already in terms of what we eat, until I saw that our sweets bar was still quite high. I asked my husband how this was possible and found out that he bought more sweets than I thought."

A similar sentiment echoing the collective responsibility for the results was voiced by C1: *"I always have the receipts with positive impact and you are always destroying our ratio!"* to which C2 responded: *"Yes, but you are only buying vegetables and fruits on the weekend, I have to buy the other stuff during the week!"*

The capability of the system to support collective awareness and collective action based on a reflection of the current status quo in a particular family could also be witnessed in household F. In the initial interview, they were surprised and even shocked by how poorly their current shopping habits looked in comparison to the food pyramid, especially in the sweets category. In F1's words: *"After we saw this we got together and decided as a family to try to drastically cut back on buying sweets."* Accordingly, their daughter F3 mentioned in the final interview: *"Whenever I got back home from school I would have a look at the display to see how we were doing."* This was seconded by her mother F1: *"F3 would talk almost everyday about the system to discuss if we were doing well."* Designing for the household as a collective also led to social facilitation and motivation of individual household members by their co-inhabitants, as exemplified in this statement by G1:

"In the beginning of the study, I looked quite often at the display. But after a few days, I stopped, you know, I don't really think that technologies like this are useful. But my son (G3) kept playing with it and always wanted to talk about the circle on the screen. Sometimes he forced me to look at the display and to discuss with him how we can further improve our circle."

Goals and Categories – Customization and Adaptation

The possibility to customize the system in terms of nutritional goals enabled the adaptation to specific user preferences. While the settings of the food pyramid were thought to be a good default and thus not changed by the majority of users, we also observed some minor and major changes initiated by the users. Some users reduced the size of the non-alcoholic beverage category to account for the fact that they mostly consumed tap water, which would not show up on their shopping bills. A bigger adaptation was carried out by participant H1, who stated in the initial interview: *"The standard food pyramid is no use to me because I'm on a low carb diet, so the default settings don't work for me."* The researcher then went on to show her the customization possibility and H1 used this to lower the goal for grains and potatoes, according to her dietary goals.

Furthermore, users could also customize the display by choosing between the two different visualizations. When asked about their preference in the initial and final interviews, all users consistently favored the Nutrition Circle visualization. While they saw that the Rising Smiley could give an approximate overview about a household's standing with respect to its goals, the detailed information about the consumption in the distinct categories was considered more useful. This is exemplified by a statement from A1: *"The circle visualization has a clear categorization, is more accurate and shows more detail"*.

Awareness, Reflection and Behavior Change

To assess the change in the users' food shopping behavior, Nutriflect compared the difference between a household's goals and what the members of this household were actually buying based on the information we received from the household's shopping receipts. The differences were calculated for each of the nutrition categories given by the food pyramid and then summed up to have an overall delta value for the household. The smaller this value was, the closer the household was to the nutritional goals of its members. Over the time of the study, we saw a very significant change in the delta for all households ($t(7)=3.86$, $p < 0.01$, paired t-test) indicating a change in the users' shopping behavior towards their nutritional goals.

The quantitative findings are in line with the results from the interviews, where e.g., B1 remarked: *"During shopping, I had the system in the back of my mind."* He also suggested that: *"It would have been useful to have even finer grained feedback, e.g. how buying one can of cola would affect how I'm doing with respect to my goals."*

E2 and A1 made similar remarks: *"When we were in the shop together and were about to buy chocolate, I would ask E1 whether it was still ok to get it or if it would destroy our circle." [E2]*

"I was standing in front of the ice cream shelf and hesitated about whether I should buy chocolate ice cream or not. In the end I decided against it because this would have meant a further increase in my sweets-sector." [A1]

This shows that users were consciously aware of the system during shopping and that the circle metaphor used by the system, where a perfect circle was the sign of a match between one's goals and actual shopping behavior, was a powerful and memorable visual heuristic. It was easy for users to latch onto and understand and it had power to persuade even though not actually present.

Completeness of the Representation

To seamlessly integrate the system with the household's existing practices, the Nutriflect prototype was designed to capture the shopping data almost automatically, with minimal need for manual data entry by the users. The small delay caused by entering the receipts into the system was either not noticed by most users or not considered relevant for the general reflection, as they used the system to get a big picture overview of their consumption patterns. Only G1 expressed her interest in having "*the timestamp of the most recent receipt on the screen*" to clarify the last purchase added to the system. The low effort regarding data entry afforded by the system was well received by the users, as many of them made clear that it would be either impractical or impossible for them to find the time for recording their food consumption over an extended period of time due to their already busy schedules. B1 mentioned:

"I can eat all kinds of bad things like fried food for lunch and a kebab on my way home without the system knowing it. This [lack of accuracy] is a small trade-off for the fact that the shopping is recorded automatically, which is key for someone to use this system in the long run."

Big purchases, with oil purchases as an example, were also a topic related to representation in one household (B). First, they were unhappy about the big impact of an oil purchase on their nutrition circle, but in the long term, the effect was seen as less problematic as it became smaller due to the influence of other purchases. Since the study was taking place in the summer, some participants supplemented their shopping with fruit and vegetables from their own gardens or farmers markets. E2 for example pointed out:

"We could have done even better in the system if it accounted for all the fruit and vegetables we ate from our own garden. Anyway, we mostly focused on reducing bad things like pork and sweets, as they were represented in the system, even though it didn't include all the good things we ate."

Users understood that the representation in the system only included foods from grocery stores and found meaningful ways to utilize Nutriflect despite this lack of completeness.

DISCUSSION

The design of Nutriflect is based on an understanding of households as complex and interrelated systems, in which the everyday practices of their members unfold. Higher-level phenomena such as healthy nutrition emerge from these practices and are influenced through ongoing individual and collective negotiation by the people that inhabit a household. Long-term food consumption patterns are an elusive factor and objective information about them is typically not available to these household members. By using Nutriflect to make these patterns visible we enabled individual and collective reflection about them and fostered a dialog about nutrition among household members.

Emergent Social Practices

The complexity of nutrition related practices could be seen in the range of social interactions catalyzed by Nutriflect. They included: constructive conversations, e.g., finding out about the individual contributions to the current position of the Rising Smiley; playful taunting, e.g., accusing other people of “destroying” the Nutrition Circle; and downright coercion, e.g., forcing others to look at the display and discuss possible further improvements. This kind of social facilitation was not prescribed or designed into the system, e.g., through explicit social comparison features, but rather emerged dynamically as people interacted with the system over time and within their specific social/cultural contexts.

Respectful Persuasion

In the design of the Nutriflect system we aimed to strike a balance between nudging people towards a more balanced nutrition and still preserving their freedom of choice. Following the ‘default option’ strategy from the domain of behavioral economics, we decided to use the food pyramid recommendations as the default option on which the comparison with a household’s actual food shopping behavior was based. Adaptation was possible to accommodate for different user preferences. As expected, most users stayed with the default option or only made minor adaptations, highlighting the fundamental importance of making well-informed design decision regarding validity and user benefit of the built in defaults, as well as the benefits of a personalization option.

Despite the automated tracking of people’s shopping behavior by the prototype, we were careful not to create a total surveillance system that would leave no wiggle room for its users. As users observed during the study, they could e.g., easily eat unhealthy snacks on the way home from work without the system noticing it. Rather than employing precision, coercion and control to persuade people, we aimed to raise their awareness and help them to improve their decisions about nutrition while respecting their personal autonomy.

Good Enough is Enough

The Nutriflect system is based on a minimalist design approach, both regarding the amount of data collected and regarding the effort for people to use the system. We consciously decided to trade off completeness of the represented data for ease of use by abstaining from integrating manual food data entry. As our study showed, this worked out well regarding our goal of enabling reflection about nutrition and improving users’ food consumption patterns. This could be termed as Pareto efficient [5] design, building on the idea of designing systems that utilize only the necessary minimum of data and users’ resources to achieve the desired outcome.

Limitations

While our study showed that there was a significant change in people’s shopping behavior over 4 weeks after the deployment of the Nutriflect system, we cannot rule out the role of other factors, such as the novelty effect of the system regarding this result. Thus, longer-term studies are needed to confirm our findings and to determine the optimal duration of deployment. Furthermore, the manual entry of grocery receipts into the system prototype led to minor delays in the feedback and the update of the presented information. However, this delay was not relevant for the long term reflection on a households nutrition patterns in our study. Yet, the manual data entry limits the scalability of the system, so a future version could fully automate the data retrieval, e.g., through a direct connection to a retailer’s database. This would further reduce the effort for the user and allow a larger scale implementation.

CONCLUSION

In this paper we contribute to HCI research with a novel approach towards making use of food shopping data generated by a household. We conducted 125 in-situ interviews to better understand supermarket customers and their needs. We designed and implemented the Nutriflect system that makes use of the already existing information about a household’s shopping behavior and visualizes this information on a situated display in the kitchen. Nutriflect allows the comparison of a household’s food consumption patterns with the food pyramid or with people’s own nutritional goals. The collective approach taken by Nutriflect showed the potential to foster reflection, catalyze conversations among household members and positively influence their shopping behavior. We hope that the results from the field study will encourage and inform further research in this area.

ACKNOWLEDGMENTS

We thank Matthias Karan and Hansjörg Hofer for implementation support and Okiemute Akpuma for support during the studies. Authors 1, 2 gratefully acknowledge the Internet Foundation Austria grant ‘Die Netidee 2012’

REFERENCES

1. *Die Ernährungspyramide im Detail - 7 Stufen zur Gesundheit*. Bundesministerium für Gesundheit. http://bmg.gv.at/home/Schwerpunkte/Ernaehrung/Empfehlungen/
2. *White Paper on a Strategy for Europe on Nutrition, Overweight and Obesity related health issues*. European Commission, Brussels, 2007.

3. *WHO Global Strategy on Diet, Physical Activity and Health*. WHO, Geneva, 2004.
4. Andrew, A. H., Borriello, G. and Fogarty, J. Simplifying Mobile Phone Food Diaries. In *PervasiveHealth 2013* (2013), 260-263.
5. Cirillo, R. *The economics of Vilfredo Pareto*. Cass, London ; Totowa, N.J., 1979.
6. Comber, R., Hoonhout, J., Halteren, A. v., Moynihan, P. and Olivier, P. Food practices as situated action: exploring and designing for everyday food practices with households. In *Proc. CHI13*, ACM (2013), 2457-2466.
7. Duhigg, C. *How Companies Learn Your Secrets*. City, 2012.
8. Ellwood, P., Innes Asher, M., García-Marcos, L., Williams, H., Keil, U., Robertson, C., and Nagel, G. Do fast foods cause asthma, rhinoconjunctivitis and eczema? Global findings from the International Study of Asthma and Allergies in Childhood (ISAAC) Phase Three. *Thorax*(2013).
9. Elmadfa, I. *Österreichischer Ernährungsbericht 2012*. 9783901861970, Vienna, Austria, 2012.
10. Erickson, T., Podlaseck, M., Sahu, S., Dai, J. D., Chao, T. and Naphade, M. The dubuque water portal: evaluation of the uptake, use and impact of residential water consumption feedback. In *Proc. CHI12*, ACM (2012), 675-684.
11. Fogg, B. J. *Persuasive Technology: Using Computers to Change What We Think and Do*. Morgan Kaufmann Publishers Inc., 2003.
12. Fogg, B. J. *The Six Most Powerful Persuasion Strategies*. Springer, City, 2006.
13. Ganglbauer, E., Fitzpatrick, G. and Molzer, G. Creating visibility: understanding the design space for food waste. In *Proc. MUM12*, ACM (2012), 1-10.
14. Grießhammer, R. and Hochfeld, C. *Memorandum Product Carbon Footprint* BMU, UBA, Öko-Institut e.V., Freiburg, 2009.
15. Grimes, A., Bednar, M., Bolter, J. D. and Grinter, R. E. EatWell: sharing nutrition-related memories in a low-income community. In *Proc CSCW08*, ACM (2008), 87-96.
16. Grimes, A., Kantroo, V. and Grinter, R. E. Let's play!: mobile health games for adults. In *Proc. Ubicomp10*, ACM (2010), 241-250.
17. Gustafsson, A. and Gyllenswärd, M. *The power-aware cord: energy awareness through ambient information display*. ACM, N.Y., 2005.
18. Kimokoti, R. and Millen, B. E. Diet, the Global Obesity Epidemic, and Prevention. *Journal of the American Dietetic Association*, 111, 8 (2011), 1137-1140.
19. Kjeldskov, J., Skov, M. B., Paay, J. and Pathmanathan, R. Using mobile phones to support sustainability: a field study of residential electricity consumption. In *Proc. CHI12*, ACM (2012), 2347-2356.
20. Kong, F. and Tan, J. DietCam: Automatic dietary assessment with mobile camera phones. *Pervasive and Mobile Computing*, 8, 1 (2012), 147-163.
21. Lee, M. K., Kiesler, S. and Forlizzi, J. Mining behavioral economics to design persuasive technology for healthy choices. In *Proc. CHI11*, ACM (2011), 325-334.
22. Maitland, J., Chalmers, M. and Siek, K. A. Persuasion not required Improving our understanding of the sociotechnical context of dietary behavioural change. In *Proc*. *PervasiveHealth 2009. IEEE* (2009), 1-8.
23. Mamykina, L., Miller, A. D., Grevet, C., Medynskiy, Y., Terry, M. A., Mynatt, E. D. and Davidson, P. R. Examining the impact of collaborative tagging on sensemaking in nutrition management. In *Proc. CHI11*, ACM (2011), 657-666.
24. Mankoff, J., Hsieh, G., Hung, H. C., Lee, S. and Nitao, E. Using Low-Cost Sensing to Support Nutritional Awareness. In *Proc. Ubicomp02,* Springer-Verlag (2002), 371-376.
25. Noronha, J., Hysen, E., Zhang, H. and Gajos, K. Z. Platemate: crowdsourcing nutritional analysis from food photographs. In *Proc. UIST*, ACM (2011), 1-12.
26. Oinas-Kukkonen, H. and Harjumaa, M. Persuasive Systems Design: Key Issues, Process Model, and System Features. *Communications of the Association for Information Systems*, 24, 28 (2009).
27. Österreichisches Bundesministerium für Gesundheit, *Österreichische Ernährungspyramide*, 2010.
28. Pässler, S., Wolff, M. and Fischer, W.-J. Food intake recognition conception for wearable devices. In *Proc. ACM MobiHoc*, ACM (2011), 1-4.
29. Purpura, S., Schwanda, V., Williams, K., Stubler, W. and Sengers, P. Fit4life: the design of a persuasive technology promoting healthy behavior and ideal weight. In *Proc. CHI11*, ACM (2011), 423-432.
30. Reitberger, W., Güldenpfennig, F. and Fitzpatrick, G. *Persuasive Technology Considered Harmful? An Exploration of Design Concerns through the TV Companion*. In *Proc. Persuasive12*. Springer, 2012.
31. Reitberger, W., Ploderer, B., Obermair, C. and Tscheligi, M. The perCues Framework and its Application for Sustainable Mobility. In *PERSUASIVE 2007*, Springer (2007), 92-95.
32. Siek, K. A., Connelly, K. H., Rogers, Y., Rohwer, P., Lambert, D. and Welch, J. L. *When Do We Eat? An Evaluation of Food Items Input into an Electronic Food Monitoring Application*. 2006.
33. Thaler, R. H. and Sunstein, C. R. *Nudge : improving decisions about health, wealth, and happiness*. Yale University Press, New Haven, 2008.
34. Tsai, C. C., Lee, G., Raab, F., Norman, G. J., Sohn, T., Griswold, W. G. and Patrick, K. Usability and feasibility of PmEB: a mobile phone application for monitoring real time caloric balance. *Mob. Netw. Appl.*, 12, 2-3 (2007), 173-184.