TECHNOLOGY-ASSISTED PERSUASION FOR DIETARY HABIT CHANGE

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Abstract:

This report explores some of the current body of research within the field of persuasive technologies, specifically in the context of health and dietary habits. Additionally, an approach aimed to explore a gap in the current body of research is proposed. Specifically, the approach is concerned with technology-assisted intervention design for shoppers when they are shopping at a supermarket. A prototype smartphone application was developed and deployed in the field to 11 participants for a total of 5 weeks of study. The persuasive properties of the prototype are facilitated by notifying the participants of an overview of their recent purchases related to the Danish food pyramid. Detailed findings are presented in the enclosed research paper, and includes just-in-time considerations for persuasive design of technologies used in an in-situ context. This report is concluded by design proposals and suggestions for further research on persuasive technologies.

PREFACE

This report documents the process of a master thesis project conducted by one software engineering student at the Department of Computer Science at Aalborg University, Denmark. The project commenced on the 1st of February, 2015, and the final submission was handed in on the 28th of May, 2015.

The project was conducted within the field of Human-Computer Interaction (HCI) with focus on persuasive technologies. This report documents an overview of previous work within this field, and an opportunity for further research is identified. A study was conducted in an effort to advance the field of persuasive technologies, in which a smartphone application was deployed to the field. This is documented in the form of a research paper, which includes reasoning behind applied research methods, analysis of the problem area, and design considerations for the approach.

The reader is expected to be familiar with commonly used terminology within the field of HCI and persuasion, as well as basic terminology within the field of computer science. Otherwise, terminology is defined throughout this report where assumed appropriate.

Thanks to all of the eleven people who participated in the field study of the smartphone application for their time and valuable feedback. Thanks to the participant in the pilot study for the help with identifying bugs in the software. Thanks to Aalborg University for providing access to the Android Developer Console, which assisted considerably in the process of deployment for the field study.

A special thanks goes to Mikael B. Skov for his supervision and valuable feedback throughout the duration of this project, which had a significant influence on the direction and quality of the research.

CONTENTS

CHAPTER 1

INTRODUCTION

In the last few years, interest has grown within the field of HCI to explore ways of persuading users with assistance from technology [5]. This concept is known as *persuasive technology*, or *captology*. Two major areas of persuasive technology currenly exists. One area is the traditional approach, which I will refer to simply as persuasive technologies, and is defined by Fogg as technology designed to change attitude or behavior through persuasion [4]. A distinction is made between systems that influence users, and systems that are designed with the intention to do so. For a technology to be considered persuasive, it must be designed with the intent to persuade, and usually with particular focus on some desired alteration in attitude or behavior [5]. This is the approach with the largest body of empirical research. The other area is gamification, which is an approach to persuasion with a focus on providing a gameful experience to the user. While gamification is certainly interesting, persuasive technologies are the focus of this report.

A large body of research has already been conducted on persuasive technologies [5]. Commonly researched domains of persuasive technologies include health and exercise, ecological consumption, and education. With an increasing rate of obesity in adults, which has nearly doubled since 1980 [16], a direction of research towards the design of technology-assisted interventions is highly relevant. The area of research on weight loss interventions has been explored substantially over the last decade [17], but some issues still remain. An interesting aspect is how to persuade users at the opportune moment, in the sense that the user is influenced at the exact moment a decision is to be made. In the context of the obesity problem, an opportune moment could be when the users conduct their grocery shopping. This is an area of persuasive research that has not yet been extensively covered. As such, the research question of this project is as follows:

> *How can a system be designed to persuade users in the supermarket to change their food consumption patterns to healthier alternatives?*

Before attempting to answer this question, an overview of relevant parts of the current body of research within health and persuasive technologies is presented.

1.1 Health and Persuasive Technologies

Xu et al. presents a systematic review of long-term weight loss interventions, consisting of 17 publications in the final analysis, with randomized control trials of a duration longer than 12 months [17]. The publications were mapped to Oinas-Kukkonen's Persuasive System Design (PSD) model [10], a derivation of Fogg's seven strategies, and the nine most common persuasive elements were used. Although not studied extensively, a significant correlation between tailoring and weight loss was found. Positive effects also showed in personalization, competition, and reminders.

Examples of work presenting positive findings related to tailoring could be Kaptein et al, who presents a study on tailored persuasive text messages [6], or Dijkstra who presents a study on smoking cessation with similar findings [3]. Langrial et al. presents a study with positive findings related to sending reminders to the participants to reduce their consumption of soft drinks [7]. Maheshwari et al. presents positive findings on the effectiveness of simple messages, positive messages, or messages that suggest a healthy alternative [8].

An interesting example of a health-related persuasive technology is a smart kitchen equipped with ubiquitous computing technology, as presented by Chi et al. [2]. Weight sensors were deployed under the counter and the stove in a kitchen, and an overhead camera was used to identify food products. A display provided information to the user on the calorie content of the food. Limitations were found to be the lack of covering nutritional balancing and food groups, and while knowledge of caloric content is useful, what is bought in the first place is not addressed. It is logical to assume that if no healthy food products are available for cooking a meal, the meal cannot contain healthy ingredients.

Orji et al. studied motivational factors for healthy eating in intervention design [11, 12]. Main findings in these studies was that males are more motivated by a concern for food choice and for females a concern for disease was more apparent. As such, interventions for males should be designed to increase the perceived relationship between unhealthy eating and weight gain, whereas for females it should be designed to increase the perceived relationship between unhealthy eating and diseases. An interesting point was the importance of focusing on a few persuasive strategies in order to retain the simplicity and usefulness of an approach. This point is also brought up by Purpura et al. [13].

Other approaches focusing on persuasion through mobile technologies includes VERA [1], as presented by Baumer et al, and Nutriflect, as presented by Reitberger et al. [14, 15]. In VERA, mobile phones are used to take pictures of decisions the participants consider healthy or unhealthy. The pictures are then shared among the participants, who claimed to have increased their nutritional awareness because of this. In contrast, Nutriflect is a combination of two systems: a situated display at home, and a mobile application to be used in supermarkets. The focus of Nutriflect is on increasing the awareness of food consumption patterns of the participants. To facilitate a presentation of the participants' food consumption patterns, receipts are registered and manually logged by the research team. Mankoff et al. presents an approach to avoid manual logging of receipts [9], where receipts are scanned by the user and the food products are inferred by image recognition software.

CHAPTER 2

RESEARCH PAPER

Food4Thought: Just-in-time Reflection in the Supermarket

As new technology makes it possible for shoppers to automatically store and access their shopping data digitally, several opportunities arise to analyze, simplify and present this data to shoppers in a meaningful way. With the increasing ubiquity of smartphone devices and the possibility for these devices to determine the context of the user, an opportunity arises to present context-aware information to the user.

Considering the obesity problem, persuasive technologies could provide information to the user with the intent to promote reflection on the user's dietary habits. While previous work has explored this area of persuasive technologies, the paper identifies and presents a gap in the research on the temporal and contextual factors in the presentation of such information. This can be rephrased as to explore the point in time and place where opportune moments for technology-assisted interventions arise, which is what the paper defines as *just-in-time* persuasion. Specifically, the paper is concerned with presentations that are noticed just-in-time at the supermarket, when the users are shopping. As the paper shows, a well-timed and subtle nudge might be what makes the difference between a healthy and an unhealthy choice of food products.

A prototype application for smartphones was developed to explore the concepts of just-in-time and in-situ persuasion. For this purpose, the application was deployed to 11 participants in a case study for 3 to 5 weeks. When a participant walked into a supermarket, the application notified the participant to get an overview of previous purchases. The participant would then be presented an overview of the most recent purchase and an average of the five most recent purchases in relation to the Danish food pyramid. The aim was to promote self-reflection on the dietary habits of the participants. Throughout the case study, activity and location data was recorded. The case study was followed by an interview with each of the participants.

Key findings were as follows: The participants found the timing of notifications to be critical, and the opportune moment was suggested to be just before or upon entering a supermarket. Issues with current smartphone technology were identified, as notifications were frequently not received, ignored, or unnoticed, which suggests that other approaches to acquire a user's attention should

be encouraged. The application was primarily used out of context, at home, while still promoting reflection in most of participants, and almost half were surprised by the information they were presented. A tendency to conduct impulsive purchases was indicated by the participants, which suggests that some food product purchase decisions are made in-situ. 45% of the participants described a situation in which reflecting upon the presented information led to a purchase they would otherwise not have made, which suggests a persuasive effect. However, most of the participants denied having been influenced by the application, which suggests a nudging effect. The representation was found to accurately represent the shopping habits of the participants, while several were unable to relate to the information in a dietary context. The critique was mostly aimed at the use of the food pyramid, and it was frequently requested to allow the participants to set their own dietary goals. This verifies the importance of tailoring, as pointed out by previous work. The non-suggestive and reflective approach of the application was well-accepted by most participants.

CHAPTER 3

CONCLUSION

In this master thesis project, previous work in health-related persuasive technologies was explored, and a gap in the research was identified. Specifically, the lack of focus on just-in-time interventions. To explore this area of research, the following question was asked:

> *How can a system be designed to persuade users in the supermarket to change their food consumption patterns to healthier alternatives?*

A prototype smartphone application was developed with persuasive design considerations in focus, and the aim was to explore possibilities for intervening with unhealthy shopping habits just-in-time and in-situ. The application was deployed in a qualitative study with a total duration of five weeks.

The study showed that the timing of notifications in interventions is critical to enhance the potential influence a notification might have. In future work I suggest that temporal factors are considered along with the context in persuasive design. Additionally, current smartphone technology was illustrated to be insufficient in consistently grabbing the users' attention. In future work I suggest that alternative ubiquitous technologies could be explored, such as the increasingly prevalent smartwatches and activity trackers.

The combination of multiple persuasive technologies is an interesting aspect of persuasive design, which is not explored extensively and is a feasible candidate for further research. For example, situated displays could communicate with smartphone devices, and as such an opportunity for an increase in in-situ information exposure along with an increase in the subtlety of the approach could be explored. Likewise, a interesting aspect of future work could be to explore cross-context properties of persuasive technologies, e.g. identification of design considerations between the contexts of home, work, shopping, stressful situations, etc. More research needs to be conducted on opportune moments of interventions.

The study also indicated a denial of influence in most of the participants who described a situation in which they were influenced, which could be a candidate to be explored more extensively. The observed unawareness of having been influenced suggests that persuasive technologies can be

designed to influence users in a way that is subtle to an extent where users do not notice the influence, e.g. nudging, and the exact properties of such a design is an interesting area for further research.

While some propositions for persuasive design have been described, other contributions in this report are the suggestions for directions of future work. This report shows that there are several areas of persuasive research that remains to be explored with currently existing ubiquitous technologies.

BIBLIOGRAPHY

[1] Eric P. S. Baumer, Sherri Jean Katz, Jill E. Freeman, Phil Adams, Amy L. Gonzales, JP Pollak, Daniela Retelny, Jeff Niederdeppe, Christine M. Olson, and Geri K. Gay. Prescriptive persuasion and open-ended social awareness: Expanding the design space of mobile health. In *Proc. CSCW12*, pages 475–484. ACM, 2012.

[2] Pei-Yu Chi, Jen-Hao Chen, Hao-Hua Chu, and Jin-Ling Lo. Enabling calorie-aware cooking in a smart kitchen. In *Proc. PERSUASIVE08*, pages 116–127. Springer-Verlag, 2008.

[3] Arie Dijkstra. Technology adds new principles to persuasive psychology: Evidence from health education. In *Proc. PERSUASIVE06*, pages 16–26. Springer-Verlag, 2006.

[4] B. J. Fogg. *Persuasive Technology: Using Computers to Change What We Think and Do*. Morgan Kaufmann, 2002.

[5] Juho Hamari, Jonna Koivisto, and Tuomas Pakkanen. Do persuasive technologies persuade? - a review of empirical studies. In *Proc. PERSUASIVE14*, pages 118–136. Springer, 2014.

[6] Maurits Kaptein, Boris De Ruyter, Panos Markopoulos, and Emile Aarts. Adaptive Persuasive Systems: A Study of Tailored Persuasive Text Messages to Reduce Snacking. *ACM Transactions on Interactive Intelligent Systems*, 2(10):1–25, 2012.

[7] Sitwat Langrial and Harri Oinas-Kukkonen. Less fizzy drinks: A multi-method study of persuasive reminders. In *Proc. PERSUASIVE12*, pages 256–261. Springer-Verlag, 2012.

[8] Megha Maheshwari, Samir Chatterjee, and David Drew. Exploring the persuasiveness of "just-in-time" motivational messages for obesity management. In *Proc. PERSUASIVE08*, pages 258–261. Springer-Verlag, 2008.

[9] Jennifer Mankoff, Gary Hsieh, Ho Chak Hung, Sharon Lee, and Elizabeth Nitao. Using low-cost sensing to support nutritional awareness. In *Proc. UbiComp02*, pages 371–376. Springer-Verlag, 2002.

[10] Harri Oinas-Kukkonen and Marja Harjumaa. Persuasive Systems Design: Key Issues, Process Model, and System Features. *Communications of the Association for Information Systems*, 24(28):1–19, 2009.

[11] Rita O. Orji, Regan L. Mandryk, and Julita Vassileva. Towards a data-driven approach to intervention design: A predictive path model of healthy eating determinants. In *Proc. PERSUASIVE12*, pages 203–214. Springer-Verlag, 2012.

[12] Rita O. Orji, Julita Vassileva, and Regan L. Mandryk. Modeling gender differences in healthy eating determinants for persuasive intervention design. In *Proc. PERSUASIVE13*, pages 161–173. Springer-Verlag, 2013.

[13] Stephen Purpura, Victoria Schwanda, Kaiton Williams, William Stubler, and Phoebe Sengers. Fit4life: The design of a persuasive technology promoting healthy behavior and ideal weight. In *Proc. CHI11*, pages 423–432. ACM, 2011.

[14] Wolfgang Reitberger, Wolfgang Spreicer, and Geraldine Fitzpatrick. Nutriflect: Reflecting collective shopping behavior and nutrition. In *Proc. CHI14*, pages 3309–3318. ACM, 2014.

[15] Wolfgang Reitberger, Wolfgang Spreicer, and Geraldine Fitzpatrick. Situated and Mobile Displays for Reflection on Shopping and Nutritional Choices. *Personal and Ubiquitous Computing*, 18:1721–1735, 2014.

[16] WHO. *Global Status Report on Noncommunicable Diseases 2014*. WHO, 2014.

[17] Anna Xu, Taridzo Chomutare, and Sriram Lyengar. Systematic review of behavioral obesity interventions and their persuasive qualities. In *Proc. PERSUASIVE14*, pages 291–301. Springer, 2014.

APPENDIX A

FOOD4THOUGHT: JUST-IN-TIME REFLECTION IN THE SUPERMARKET

Food4Thought: Just-in-time Reflection in the Supermarket

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ABSTRACT

New technology provides an opportunity for people to access their shopping data digitally. With an increasing prevalence of overweight and obesity and the implications that follow, research on diet interventions is in high demand. This paper describes a study of the Food4Thought system: an approach to persuasive technology that focuses on providing information to users just-in-time and in-situ. A smartphone application was implemented and deployed to eleven participants over a period of three to five weeks. The application notified the participants of how their dietary habits related to the food pyramid when they entered a supermarket. Activity data was recorded and interviews were conducted. The findings illustrate that most participants reflected on their dietary habits, while almost half described a change in their shopping habits. Conflicting statements showed that most of these participants were unaware of having been influenced, which suggests a nudging effect.

Author Keywords

Behavior change; in-situ; mobile persuasion; nudge; nutrition; reflection; shopping patterns; tailoring.

ACM Classification Keywords

H.5.m. Information Interfaces and Presentation (e.g. HCI): Miscellaneous

INTRODUCTION

Within the field of HCI, a large and growing body of research has been conducted on how to design persuasive technologies that are effective in the intervention of unhealthy eating habits [25]. With an increasing prevalence of smartphones, it is interesting to explore the technological opportunities that these devices provide. This paper presents how previous work on technology-assisted intervention design has primarily been concerned with interactivity and features. Common themes of previous work have been the design and usage of shopping assistants, situated displays in the home, text messages, and mobile applications. While previous work on persuasive technologies has touched upon context-specific interventions, a gap in the work has been observed in when and where the opportune moment for persuasion occurs. While candidates for opportune moments to intervene unhealthy eating habits are numerous, the focus of this paper is on shopping habits, under the assumption that what is bought is a close reflection of what is eaten. This paper is concerned with the design of shopping habit interventions that are conducted in-situ and *just-in-time*. In this paper, just-in-time persuasion is defined as *interventions that are conducted at opportune moments*.

In 2013, a preliminary, unpublished study was conducted in a grocery store in El Paso, TX, USA on an idea involving a mirror at the end of a shopping cart [17]. The study was conducted by associate professor Payne, Collin and assistant professor Niculeascu, Mihai, both working for the Marketing Department of New Mexico State University, NM, USA. While no data from the study was published, it was indicated that the gentle nudge provided by the mirror resulted in an increase in produce sales as well as a decrease in sales of other food products. It was claimed by several participants that the mirror had an effect on their self-perception. Along with increased sales of produce, this suggests that a mirror has a direct influence on a shopper's food-purchasing patterns.

Figure 1. The Food4Thought prototype viewed in-situ.

Based on the idea of this study, the *Food4Thought* prototype application for smartphones has been developed to facilitate in-situ, technology-assisted self-reflection. The prototype is presented in Figure 1. New technology provides an

opportunity to automatically collect an individual's shopping data [13], which aids Food4Thought in facilitating a tailored and a reflective approach. A case study was conducted, using Food4Thought as a research tool to investigate technological opportunities for persuading grocery shoppers to change their food-purchasing patterns to healthier alternatives. As such, the research question of this paper is as follows:

> How can a system be designed to persuade users in the supermarket to change their food consumption patterns to healthier alternatives?

Following in this paper, the background for this paper as well as related work is presented, after which the Food4Thought prototype is described. Subsequently, a case study is presented in which the prototype is deployed to the field, and the setup and the participants of the study are described. The findings of the case study are then presented, and is followed by a discussion on the aggregated findings. Finally, the conclusion summarizes the key points of this paper.

BACKGROUND AND RELATED WORK

Persuasive technology is defined as technology that is designed to change the attitude or behavior of the users through persuasion [4]. With a body of 95 studies on persuasive technologies [9], it is trivial to infer that a substantial amount of effort has already been put into research within the field of persuasive technologies. In turn, it is thus a non-trivial task to decide in which direction to extend the research. In this section, a number of publications related to Food4Thought are presented. Generally, the publications included in this section are used to elaborate on the direction of the study presented in this paper. Throughout this section, common terms of persuasive technology defined by Fogg [4] are used, such as the seven strategies to influence behavior: reduction, tunneling, tailoring, suggestion, self-monitoring, surveillance, and conditioning. The reader is expected to be familiar with such terms. First, studies with a focus on reflective persuasion as well as studies published within the field of mobile persuasion are presented. Following is a presentation of studies within the field of persuasive technologies that are related to nudging in-situ. This provides the reader with a brief overview on the directions of the field as well as the distinctive qualities of Food4Thought. Finally, the problem area is defined and presented, and the research directions as well as the research methodology for Food4Thought are outlined.

Reflective and Mobile Persuasion

A variety of publications, in which persuasion facilitated by mobile technologies is investigated, have been published. Mankoff et al. presents a system where receipts are used to acquire data on a user's grocery shopping habits [16]. The receipts are scanned manually by the user, and the food products are then inferred by image recognition software. Healthy food equivalents are then suggested to the user based on nutritional deficiencies calculated from the historical shopping data. The system was initially developed in 2002 with the intention for the user to print out a shopping list, which includes suggestions to healthier alternatives of food products, and bring it to the supermarket to be used in-situ. However, it is trivial to envision how current mobile technology could conveniently carry out all tasks of the system, including photographing receipts, scanning, inferring, and suggesting healthier alternatives while at the supermarket. No studies were conducted on the system in practice. Food4Thought also uses shopping data, but remains non-suggestive in addition to being tailored to the user.

Nutriflect is a similar system incorporating the use of shopping receipts to assess food consumption patterns [21, 22]. The focus of Nutriflect is to present the collective food consumption patterns of a household through situated displays in the home, known as Nutriflect home, as well as through mobile devices in the supermarket, known as Nutriflect mobile. Receipts are manually entered by the research team, and the data is then presented in an alternative form of the Austrian food pyramid, giving cues to a household on how well their collective food consumption patterns fit their nutritional goals. Additionally, Nutriflect mobile can be used to interact with products in-situ via *near field communication* (NFC) technology. When the RFID tag of a product is scanned, the application will show on the food pyramid how buying the product will affect the user's dietary goals. Comparatively, Food4Thought is simpler being that the focus is entirely on mobile technologies and minimal interaction is initiated by the user. Additionally, in Food4Thought, the process of receipt data acquisition is automated.

VERA is another system focused on mobile health with a reflective approach [2]. Specifically, VERA is proposed as as a system facilitating open-ended social awareness as a central principle, with "open-ended" indicating that no actions are prescribed to the user. Mobile phones are used to take pictures of healthy or unhealthy decisions, which then are shared among the users in a common space. While eating behavior was not studied, the participants reported becoming more nutritionally aware. However, a drop off of self-reporting was noticed a few weeks in, which was attributed to user fatigue or lack of motivation. This suggests that self-reporting can be highly reliant on the novelty of a system. In Food4Thought, the open-ended and reflective approach is adopted, while no self-reporting is performed by the users.

Other studies have been conducted, in which sending text messages to participants was in focus [11, 14, 15]. Main derivations from the studies are as follows. Tailoring was found to be highly effective [11], while daily reminders have been reported to be welcomed [14]. Although in the context of smoking cessation, Dijkstra finds similar results regarding the effectiveness of tailoring [3]. Health care expert calls generally have higher credibility than generic text messages, and an effective approach to messaging is to provide positive or simple messages, or messages that provide a healthy alternative to an unhealthy action [15]. A common assessment from these studies can be made, acknowledging the difficulties in designing suggestive and persuasive messages. As mentioned, in Food4Thought suggestive messages are of no concern. Food4Thought is built upon insights acquired from

these studies, with special focus on the importance of tailoring, positivity, and simplicity in persuasive design.

Nudging In-Situ

Ganglbauer et al. conducted a qualitative study on food waste, including daily food practices, shopping planning, and more [7]. Of 11 participants, all with the primary responsibility to organize and carry out shopping in their respective households, around half did not use a shopping list. Of those who did, a number of participants admitted that the shopping list was not definitive and commonly used as a guideline. This is consistent with the findings of Thomas et al, stating that 67% of 262 interviewees claimed to have used a shopping list during their last major trip to the supermarket [24]. From this, it can be deduced that not all shopping decisions are made at home, thus an opportunity to influence shopping habits in-situ is apparent. An interesting aspect of in-situ persuasion, is the issue of how to integrate the concept of nudging to influence food shopping habits, so as to better integrate the idea of the shopping cart mirror. As originally defined by Thaler and Sunstein:

> *A nudge, as we will use the term, is any aspect of the choice architecture that alters peoples behavior in a predictable way without forbidding any options or significantly changing their economic incentives.* [23, p. 6]

An example of nudging in-situ in supermarkets, is a study by Kalnikaitë et al. using a lambent shopping handle on shopping carts [10]. The lambent shopping handle provided feedback on scanned products, specifically food mileage, food mileage compared to the social norm, and whether or not the item is organic. A difference between food products bought by participants in the control group versus the group with the modified handle was apparent for a majority of items. The study showed that in-situ nudging made participants think about their choice of products as well as alter the content of their shopping carts, as 72% of the products had a lower mean food mileage compared to the control group.

Problem Area and Research Methodology

Through a review of 95 studies on persuasive technologies, Hamari et al. have identified the common pitfalls of persuasive research [9]. To avoid some of these, the focus is to make a distinction between whether or not the participants are trying to acquire healthier dietary habits regardless of using Food4Thought. Food4Thought is kept simple in order to effectively study its affordances individually rather than as a whole. In this section, problems were identified in related work regarding manual entering of data, too high complexity in study designs, as well as high data input requirements of study participants. Food4Thought is kept simple and implements a minimum of persuasive strategies, facilitates automatic acquisition of digital data, and places no demands on participants regarding data input. This ensures results that are clear, valuable, and sufficiently informative. Additionally, Food4Thought is based on the eight-step design process, as proposed by Fogg [5]. The suggested approach is described in the following section.

THE FOOD4THOUGHT SYSTEM

Food4Thought aims to automatically collect and analyze shopping data, create a simplified representation, and present the data to shoppers just-in-time when they are shopping in a supermarket. Specifically, historical shopping data is presented in relation to the Danish food pyramid, which is well-known among Danish residents. The Danish food pyramid, as presented by Fællesforeningen for Danmarks Brugsforeninger (currently known as Coop amba), aims to guide the general public towards achieving a balanced diet [6]. The food pyramid is a simple illustration of which foods to eat, along with the distribution of categories of food products that is required to achieve an optimal dietary balance. The Danish food pyramid is presented in Figure 2.

Figure 2. The Danish food pyramid [6].

The layers of the Danish food pyramid are as follows:

The top layer represents 13% of the food pyramid, and consists of poultry, fish/seafood, pork, eggs, vegetable oils, beef, and cheese.

The middle layer represents 44% of the food pyramid, and consists of dairy, wholegrain bread, grains, fruits, juice, and nuts.

The bottom layer represents 43% of the food pyramid, and consists of vegetables, potatoes, rye bread, and oats.

In Food4Thought, food products acquired from receipt data are categorized according to the food pyramid. As a result, food products that cannot be categorized under any of the layers of the food pyramid will be omitted from the data presented to the shoppers. This includes food products of categories not present in the food pyramid, such as sweets, as well as prepared meals that do not directly fit a single layer, such as sushi. The shopper's simplified data representation is presented on the shopper's smartphone, which allows for the possibility to track the location of the shopper. The data is then presented when the shopper is in close proximity of a supermarket. Hopefully, the presentation will motivate the shopper to reflect on past purchases and have some persuasive effect towards changing the outcome of the shopping session. For the purpose of this approach, a prototype mobile application was developed and supported by a back-end ind the form of a web service. The mobile application is developed

for shoppers with the intent to be used in-situ. The web service supports the mobile application by providing up-to-date data over the Internet. Additionally, the web service is used administratively for submission of digital receipt data. The implementation and usage of these two components are described in the following sections.

Interaction Design

The application, namely "Food 4 Thought", is developed for the Android platform for smartphones. Android was chosen since it is a prevalent operating system among smartphone users, as well as due to the accessibility of development tools for Android. The application is developed to run on Android 4.0 (Ice Cream Sandwich) and newer versions, which currently is 92.7% of all mobile phones running Android [1].

The following scenario explains how a shopper could experience the application:

> A shopper enters a supermarket, after which her smartphone notifies her to get an overview of her previous purchases. The notification consists of a message, as presented in Figure 3, as well as 3 short vibrations, the default system notification sound, and coloring of the light emitting diode of the device in bright red. The shopper can ignore the notification, but chooses to touch it. The application is then launched with its single view, in which a representation of her past purchases in relation to the food pyramid is shown. Figure 4 shows the application view. The shopper considers the information briefly, after which she carries on with her shopping agenda. When she leaves the supermarket, the notification is automatically dismissed. She can, at any time, launch the application from the home screen of her smartphone.

By launching the application, the shopper is presented with a distribution of food products between the three layers of the food pyramid. A distribution for the most recent purchase is shown along with a distribution for the average of the five most recent purchases, respectively. The presented data is based the user's purchase history, and is provided by the web service. The distribution defined in the food pyramid is based on weight; information which is not present in the receipt data. The data used to calculate the distributions shown in the application is the cumulative amount of money spent on food products for each category, respectively. A data connection is assumed when accessing the view, otherwise an error message is displayed along with a button including a message that translates to "Retry later".

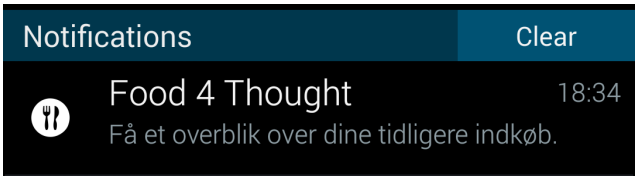

Figure 3. The notification, as presented to the shopper. Translated to English, the message says "Get an overview of your past purchases".

The locations of the supermarkets are registered as *geofences* via the *Google Play Services* application programming interface (API). In the context of Android, a geofence is a circular geographical region, generated by a set of longitude and latitude coordinates as well as a radius, and marks a location of interest. The Google Play Services API takes care of monitoring of the user's location and provides a programming environment in which common concerns of developing positioning services are handled automatically, such as optimizing for power efficiency as well as which location services to use and when, including the Global Positioning System, wireless fidelity (WiFi), and mobile phone towers. Following, the web service is described.

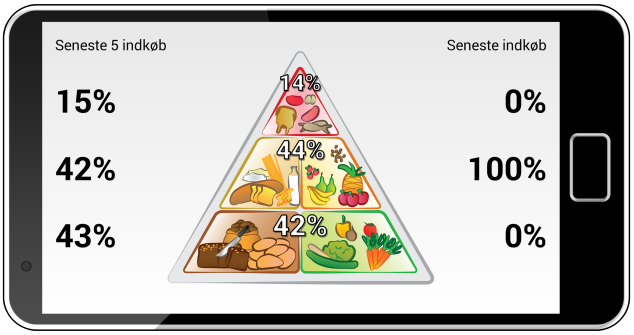

Figure 4. A sample of a shopper's purchase history in context of the food pyramid. To the left the average distributions of the last 5 purchases are presented. In the middle the food pyramid is presented, along with the ideal food distribution. To the right, the distribution of the most recent purchase is presented.

Web Service

The web service is written in PHP and supported by a MySQL database. Shopping data is submitted to the web service continuously as receipts are generated by users when they are shopping. After submission, the food products from the shopping data are then categorized according to their food groups. Non-food products, as well as composite meals that do not belong directly to a single food group, are not categorized. A food product needs to be categorized the first time it is submitted to the database. Any identical food products added subsequently are automatically categorized under the same category. To ensure correctness, categorization is a manual process and is performed continuously as new receipt data is submitted to the database. Other submissions to the web service are:

- The time and location when a shopper enters a supermarket.
- The time and location when a shopper exits a supermarket.
- The time when a shopper opens the application.

Data from these submissions is not presented to the shoppers.

A case study, in which the Food4Thought system was deployed in the field, is described in the following section.

DEPLOYMENT

A case study was conducted over a period of 5 weeks with 11 participants who each used the Food4Thought application for 3 to 5 weeks on their own smartphone devices. The aim was to explore how the participants used the application in their everyday lives, with focus on in-situ usage, as well as the reflections they made based on the information they were presented.

Participants

The participants in the case study were as follows:

M01: Male student (26 years old) with above average smartphone experience, who shops for him and his girlfriend.

F02: Female consultant (50 years old) with above average smartphone experience, who shops mainly for herself and sometimes for her boyfriend.

F03: Female student (26 years old) with average smartphone experience, who shops mainly for herself and sometimes for her boyfriend.

F04: Female secretary (50 years old) with above average smartphone experience, who shops primarily on weekdays for herself, her husband (M06), and two children.

F05: Female senior citizen (77 years old) with below average smartphone experience, who shops for herself.

M06: Male project leader (46 years old) with average smartphone experience, who shops primarily on weekends for himself, his wife (F04), and two children.

F07: Female team leader (48 years old) with average smartphone experience, who shops for her, her husband, and one child.

M08: Male plumber (55 years old) with average smartphone experience, who shops mainly for himself and sometimes for his girlfriend.

F09: Female cleaner (50 years old) with above average smartphone experience, who shops for her, her husband, and one adult child.

F10: Female care pedagogue (51 years old) with below average smartphone experience, who shops mainly for herself.

F11: Female union worker (58 years old) with average smartphone experience, mainly shopping for herself.

The participants were recruited through the Facebook social network on various groups associated with the city of Aalborg, as well as through my extended network. One gift card with a value of 200 DKK (approximately 30 USD) was offered in a draw between all participants as an incentive to participate. The requirements for participating were that participants must:

i) own a smartphone device running Android 4.0 or greater,

ii) be willing to register on Kvittering.dk and provide the credentials,

iii) conduct some of their grocery shopping in the chains of Dansk Supermarked, and

iv) be based in or within a 10 kilometer radius of Aalborg.

None of the participants were registered on Kvittering.dk prior to the case study, which had implications for the amount of available digital receipt data when the study commenced. The participants had varying levels of experience with smartphone devices, ranging from inexperienced to very experienced, with the majority having approximately average experience. All of the participants stated they were familiar with the food pyramid prior to the case study. Nine of the participants were residing in distinct households, and two were residing in a shared household (F04, M06) and shared the task of grocery shopping. Nine participants stated they had a goal of losing weight or improving dietary habits.

All of the participants were informed about the functionality of the application and instructed to carry out their grocery shopping as they normally would. No special instructions were provided regarding usage of the application, in order to assert how the application would be used naturally by the participants. Three participants were provided with in-person assistance in order to set up the prerequisites for the case study.

Study Protocol

During the five weeks of study, tasks included monitoring of location and application activity, extraction of digital receipt data, and categorization of product data. The study period terminated with an interview with each of the participants.

The participants were initiated in the case study over a period of two weeks as they announced their interest in participating. The initiation period of the study consisted of setting up the prerequisites for the case study. Specifically, all of the participants were sent an e-mail that provided basic details about the functionality of the application as well as instructions on how to set it up. Additionally, the participants were asked to provide their credentials to their Kvittering.dk accounts as well as to provide the e-mail account with which they had registered their smartphones. Their details were registered on the web service, after which the participants were informed that the application was ready for use. All participants verified that the application was working as per instructions. Throughout the period of the study, I did not interfere with the activities of the participants and they were left to act as they pleased. However, I did answer questions from participants when asked.

During the deployment period of the study, I extracted data from Kvittering.dk and submitted it to the web service at least once per day, immediately followed by categorization of the food products. Location activity was monitored twice per week, so as to ensure that data was being sufficiently generated and provided by the participants. If irregularities were observed in registering of location activities, the affected participants were notified so as to open up for the possibility to find a solution. Such irregularities could be the result of system settings on a device being improperly set up, which

would result in a lack of data registering or absence of notifications. Affected participants were offered in-person assistance.

On cessation of the deployment period, the participants were asked for an interview. Participants were interviewed in person when possible, and otherwise over the phone. The interviews were semi-structured and the aim was two-fold. The first part of an interview focused on basic details about the participants, such as age, occupation, and familiarity with the food pyramid, as well as acquiring insights into the participants' thoughts and reflections on their regular shopping habits. The second part focused on how the application was experienced and used in various contexts, as well as thoughts and reflections on the deployment period that could indicate a change in thought or behavior in the context of shopping habits. The primary focus was to investigate these properties in an in-situ context. The structure of the interview guide was altered after the first two interviews to accommodate for more open-ended natural conversation and to incorporate more aspects considered interesting by the first two interviewees. The interviews were recorded for later transcription. After the interview, the participants were instructed to uninstall the application.

Shopping Data Source

New technology automatically provides digital shopping data to consumers, specifically the Danish company Kvittering.dk. By signing up with the service, shoppers receive their receipts digitally from a limited selection of stores when a purchase is completed using a payment card that is registered on the service. Shopping data is extracted from Kvittering.dk and submitted to the Food4Thought web service once per day. In the context of food products, the supermarket chains of Dansk Supermarked are the only stores currently cooperating with Kvittering.dk, specifically Netto, Føtex, Bilka, and Salling. All supermarkets in the city of Aalborg, Denmark, and within a radius of 10 kilometers have been identified, totaling 98 supermarkets. Currently, the four supermarket chains of Dansk Supermarked represent 20 of the 98 supermarkets. Although collections of address-based supermarket locations were available, the locations of the supermarkets were recorded manually in a geographical coordinate system to ensure that notifications were shown at appropriate locations only.

Extraction of Digital Shopping Data

According to Kvittering.dk, at present time, the API of Kvittering.dk is not accessible to third parties. Additionally, the API used on the website is protected from cross-origin resource sharing. This makes it impossible to acquire data, which requires authentication, from the website from a remote server. Injecting JavaScript via the browser allows for the possibility to run client-side code on a website from the same origin as the website. To compensate for the limitation of the API, I wrote a function in JavaScript that takes a set of user credentials for Kvittering.dk and returns an alert message on successful data extraction and subsequent submission to the web service. The user credentials are provided with consent from the participants in the case study. When the JavaScript function is executed in a web browser that has been preloaded with the website of Kvittering.dk, each user is authenticated and a set of the five most recent receipts from each user are collected. The relevant receipt data is then stored in JavaScript Object Notation (JSON) format, and passed collectively to the Food4Thought web service.

Pilot Study

A pilot study was conducted in advance of the case study, in order to identify and address bugs and inconveniences before deploying to all participants. The pilot study consisted of one male participant, who was an experienced smartphone user. The pilot study was conducted over a period of three weeks, during which he used the application continuously in the cities of Århus and Aalborg, Denmark. Development of the application was carried out in parallel with the pilot study. and additional requirements for the application were created continuously, based on the findings. Additionally, the pilot study was conducted to gain experience with handling participant data, in order to decrease the risk of surprises that could impact the case study negatively. This approach is in accordance with Fogg's suggestion to "test and iterate quickly" [5].

Data Analysis

All interviews were partially transcribed for data analysis. Specifically, all parts of the interviews were transcribed in a resume style, with full transcription of key sentences suitable for evidence. In addition to the interviews, the data that was recorded throughout the case study was analyzed. Specifically, the data on application, location, and purchase activities. The activity data was formally analyzed prior to each interview, and events were constructed based on activities with temporal similarities. Specifically, daily activity data was combined for each participant, and a comment was written for each set of daily activities. This laid a foundation for discussing interesting sets of activities with the participants during the interviews, as well as cueing the participants to recall events. With inspiration from grounded theory as presented by Glaser and Strauss [8], the data was analyzed in context with the interview transcriptions to match the claims of the interviewees with the activity data as well as to discover possible contradictions. The transcriptions were analyzed by means of naive reading, as well as categorization of key points into a collections of recurring themes. This provided an overview of the most discussed themes, and thus a better understanding of the key themes brought up by the participants was acquired. The themes were considered in context of related research and ordered by importance.

FINDINGS

The findings have been categorized under three major themes and are described in this section. The aggregation of themes identified during data analysis provides structure for the presentation of the findings. The major themes are just-in-time and in-situ awareness, self-reflection and behavior change, and features and data representation. The themes and the key findings are presented in Table 1. Occasionally, the number of participants behind an observation is referred to. An example could be (8/11), which would refer to eight out of eleven

Just-in-time and In-situ Awareness	Reflection and Shopping Habits	Data Representation
Most participants attested to the importance of receiving notifications just-in-time, when entering a supermarket.	Most participants reflected on their shopping habits and almost half were surprised by the presented information.	The participants found the representation to accurately reflect their shopping habits, while few participants found that it did not accurately reflect what they eat.
The participants primarily used the application out of context, at home.	Several participants frequently used shopping lists, but were prone to purchase impulsively regardless.	Several participants disagreed with the principles of the food pyramid. It was commonly suggested to implement tailoring of dietary goals.
Notifications were received unreliably, and were frequently ignored or went unnoticed.	Several participants described a situation in which a purchase was made due to the presented information. Most of them later denied having been influenced by the application.	The non-suggestive, non-judgmental approach of the application was well-accepted by most of the participants.

Table 1. Key findings of the case study, organized under three major themes.

participants. All quotes have been translated from Danish to English.

Just-in-time and In-situ Awareness

The primary focus of the study was to explore how information provided just-in-time and in-situ could promote awareness of shopping habits. All of the participants brought their smartphones with them while shopping, as expected. In total, 133 notifications were received by the participants and 146 receipts were acquired. The participants opened the application 9 to 48 times (M=17.5), with a total of 192 application launches. While the majority of the participants (9/11) had received notifications during at least one of their shopping sessions, two participants (F05, M08) did not have access to location services, and one participant (F07) had not received any notifications. Excluding the three participants who did not receive any notifications, each participant received 2 to 24 notifications (M=14.8). This is comparable to the number of recorded receipts at 4 to 46 (M=13.3) per participant. It was observed that the participants often did not notice the notifications when in-situ, which could indicate that additional methods are needed for acquiring the attention of people. Of the six participants who received and noticed the notifications, almost all of them stated that the notifications were primarily noticed upon entrance or shortly thereafter (5/6), whereas the remaining participant (F10) stated that the notifications were primarily noticed later in her shopping sessions. Two participants (M01, F10) stated that occasionally they did not receive or notice the notifications until after a shopping session.

> *Sometimes I did not notice it* (the notification) *until later, because I had my phone in silent mode or I was unable to hear it or something else happened ... but when I got home I looked at my phone and noticed it.* M01

As was indicated during the interviews, notifications had more potential for influence when noticed upon entering a supermarket. The majority of the participants attest to the importance of the timing of the notifications (8/11), which is elaborated on by a participant, about a situation in which she noticed the notification while standing in line, two minutes prior to checking out:

> *If I, from the point where I enter the store, know that I just need the products I intend to buy, then it is easier to stick to ... When you are at the checkout, then it is too late ... then a notification from the app will not be enough.* F03

This is confirmed by F05 on timing of the notifications: "*Just before I go inside [the supermarket] or just after, not when I am at the checkout.*". Another participant (F10) stated that she mostly had received notifications in the middle of her shopping sessions, or immediately after. This can be related to her shopping data, which shows that she did not open the application during any of her shopping sessions.

Several of the participants who noticed the notifications mentioned that they initially misinterpreted the notification as a personal message (3/6). In some cases this resulted in the participants immediately checking their phones, out of curiosity. M01 elaborates: "*When I get there it beeps. Then I think I got an SMS. I see that it is the app, I look at it, and put it back in my pocket*". Similarly, he elaborates on a situation where he experienced getting a notification while passing by a supermarket.

> *When I hear it* (the phone) *say beep I think it is an SMS or an e-mail, and I often get disappointed when it is just a boring e-mail. It is similar with the app. I think to myself: "oh it is just the app" and figure that it is irrelevant, as I am not going shopping. But it is not a nuisance at all.* M01

Two participants experienced receiving several notifications in a row in-situ, but it was not followed up on how that situation was experienced. Two participants (F04, F09) had not noticed any notifications, despite having received seven and twelve notifications over a period of three weeks, respectively. F04 elaborates: "*I do not remember hearing the notifications ... my phone is usually in my purse, and it is not very loud*".

The majority of the participants claimed to have opened the application during a shopping session at least once (8/11). Some participants opened the application in-situ, despite having missed the notification. F02 elaborates: "*Sometimes I have my phone in my purse and I do not notice the notifications, but I open the app anyway*". The shopping data of the majority of the participants who received notifications indicates a preference for opening the application outside the context of a supermarket, with 19.3% of the application launches occurring in-situ (37/192). In contrast, few participants (4/11) claimed a preference for opening the application

out of context. For example, F07 stated that she primarily opened the application at home, usually after a shopping session: "*It was not until I got home ... to see what [numbers] had changed*". Another example explains one of many obstructions that might interfere with opening the application:

> *I did not think about it. I looked afterwards ... One time I forgot it because I was having a conversation with my neighbor...* F11

None of the participants consistently opened the application after receiving a notification in-situ and just-in-time, which indicates that other approaches able to increase the exposure of information should be encouraged as well.

Reflection and Shopping Habits

Essential aspects of persuasive technology includes promoting change in behavior as well as attitude. One focus of the study was to explore the properties of self-reflection that Food4Thought could facilitate in-situ, as well to identify potential changes in the shopping habits of the participants as a result of the case study.

Most of the participants (9/11) had concrete dietary goals, whether related to weight loss or well-being. While the participants had varying levels of commitment to nutrition goals, all of them were mindful of health factors of the food products they considered while shopping. For example, 4 participants mentioned organic foods as a preference and 6 participants mentioned calories, fats, proteins, or carbohydrates as factors. Additionally, pricing or sales were mentioned as factors by all of the participants. All of the participants claimed to be aware of their dietary habits before the study, while some participants (6/11) were surprised by the information the application presented. Reflections included participants being surprised about their dietary habits, as stated by F05: "*It should be 14% so I have bought quite incorrectly ... it surprises me*". Other participants were more considerate of the data that was omitted, such as F10 who said: "*Some of my milk, cheese, and egg purchases are not included ... but I believe it would be fun to see if I chose to buy those for some time* (in a store where it is recorded)". Almost all participants (10/11) admitted to having reflected upon the presented information in context with their dietary habits, while one participant claimed to not have reflected upon the information. As she explains:

> *It is not what directs my shopping habits ... I am not saying it is not interesting* (the information) *but I think it is like losing weight ... that you tend to relapse and eat what you are used to eat ... It is probably a matter of getting more experience with it* (the application), *but experience tells me that you usually relapse into doing what you have always done.* F09

Considering she also did not notice any of the notifications, her reaction is not surprising. All of the participants were aware that data was extracted from chains of Dansk Supermarked only, and while some of the participants had considered this fact when deciding where to shop, only one participant (F10) claimed to have made changes in her choice of supermarkets out of self-interest. She elaborated: "*I did it for my own sake and to become aware of my shopping habits, because I never gave it any thought*".

Although the participants often have an idea of what products to buy, not all shopping sessions were entirely planned in advance. Although several of the participants (5/11) regularly use shopping lists, all of them admitted to being prone to buy impulsively, illustrating that some shopping decisions are made in-situ.

> *Normally I make a shopping list ... I shop on my way home from work ... I usually forget to bring the shopping list, and when I do I usually buy all kinds of products ... when I bring the list it still happens, but not as much.* F07

Five participants (F03, M06, F07, F10, F11) admitted having made a purchase they would otherwise not have, due to information presented in the application.

> *Last time I was in Føtex it* (some numbers in the application) *looked way too low ... the three fruits or what you are supposed to eat, I probably fail to get that most of the time ... then I bought some bananas and raspberries and the like. The next day it* (the numbers) *looked so much better, which I thought was great.* F11

Interestingly, a contradiction was made when F11 afterwards claimed to not have been influenced to purchase anything she would not otherwise have:

> *It presents an overview of what you buy, as well as awareness about it, but generally I think I would have bought the same products anyway.* F11

Three other participants (F03, M06, F10) showed similar behavior towards denial of influence, while each provided a concrete and descriptive example of a shopping situation that contradicts the denial. This was surprising, although it was expected that most participants would not directly use the presented information in a conscious way, as the presentation was designed to raise awareness and promote reflection, and not to provide information that is directly actionable. In the case of M06, he described a situation in which he decided to purchase what he considered as unhealthy food due to the information he was presented:

> *I was shopping groceries. I was happy about the numbers. They were great since I only had bought products from the bottom* (of the food pyramid). *Then I thought to myself that I might as well buy some chocolate and the like ... I also remember I bought a pie.* M06

In total, nine of the eleven participants claimed to have retained their regular shopping habits. Common for most of these participants was critique of the representation of data. The next section goes into details with the findings on data representation.

Data Representation

Although not the primary focus of this paper, interesting findings were discovered during the interviews from ideas brought up by the participants from their experiences with

interacting with the application. As expected, the presented information and the features of the application were the most commonly critiqued aspects of Food4Thought. The feedback was primarily related to the decision of using the food pyramid, the granularity and tangibility of the presented information, as well as feature requests.

The participants generally found the representation to accurately reflect their shopping habits, although several participants (5/11) mentioned that they were aware of some of their purchases or meals being excluded. In most cases this had to do with purchases made outside of Dansk Supermarked chains, while two participants mentioned following a lunch scheme at work. Additionally, two participants pointed out the exclusion of unhealthy foods from the representation. Two participants (F04, M06) said that they did not find that the representation accurately reflected what they were eating. F04 elaborated:

> *This just shows that we had ran out of some things, which I then decided to buy ... Either someone in my house baked a lot or we bought the rye bread from the baker ... It does not reflect how we eat, but how we shop.* F04

As F04 and M06 were shopping for the same household, they agreed that the representation would be more accurate if they combined their data.

All of the participants said they were familiar with the Danish food pyramid prior to the case study, and usually they had been aware of it for most of their lives. When asked to define the Danish food pyramid, seven participants were able to describe it correctly, whereas the remaining four participants either mixed up the categories or mentioned categories that are not represented. Some of the participants (4/11) critiqued the choice to present the food pyramid in the application. In all cases the critique was founded in the participants having other dietary goals than those defined by the food pyramid.

> *The representation was not specific enough, and also I fundamentally do not believe in the food pyramid. I think it is about tailoring to my dietary goals and not those of the average Dane ... A lot of people who just want to retain their weight are also following a low carb diet.* F02

All of the participants who had special dietary goals acknowledged that a representation, which is tailored to their specific goals, would be more interesting for them. There was a general consensus among the majority of the participants (7/11) on implementing the concept of tailored dietary goals in the application. An often suggested approach was to emphasize the food groups the participant had particular interest in tracking. Several participants mentioned being interested in the specific food groups they usually found to be an issue. For example, fruits and vegetables were commonly mentioned to be lacking, and sweets, cake, and bread were commonly mentioned to be eaten in excess. Of those who were interested in dietary composition, a frequently mentioned point of critique was the lack of a representation of unhealthy food groups.

It was often mentioned by the participants that the non-judgmental approach of Food4Thought was welcomed, in the sense that the application did not tell the participants what they were doing wrong. F03 elaborated her opinion:

> *Offhand, if I were to use an app like that it would have to be motivating and not tell me what I do not buy enough of, etc. I think it is good that the representation of the app is more general. It would annoy me if it felt like a lecture, which it did not ... That was great, otherwise I would not use it.* F03

Another participant elaborated on his negative experience with the representation of data:

> *One thing is information on which food groups you have bought earlier. It has to be more specific and usable, like if it* (the application) *says "you should buy more meat, since your previous five purchases showed you do not buy enough". Then it is more tangible, in my opinion ... A feature could be implemented where you set your own goals, and then the app could remind you when you deviate from those goals.* M01

It is not surprising that the participants do not agree on a common representation, as it was expected that no single variation of representation would fit everyone. The findings are in line with previous research in which the importance of tailoring is also mentioned. An interesting feature was requested by P03, who wanted to use the application at home to design her shopping lists with assistance to adhere to her dietary goals. She would then like to notified of the shopping list when in-situ.

DISCUSSION

The approach of Food4Though was deployed to eleven participants to explore important properties for systems designed to persuade users in-situ, specifically in the context of dietary shopping habits. The findings show that the participants found the timing of notifications important, but the presented information was also valuable for most participants when out of context. Furthermore, the participants tended to miss the majority of the notifications due to the participants either ignoring, not receiving, or not noticing the notifications. While close to half of the participants did not change their shoppings habits, most of the participants who did were unaware of being influenced by the application. The participants found that the application accurately reflected their shopping habits, and the approach of the representation was generally well-accepted. However, several participants disagreed with the use of the food pyramid, as they had other dietary goals. The following sections present discussions on the findings of the case study, as well as design implications for persuasive technologies and propositions for future work.

Timing and Location

The findings indicate an opportunity to reach users in-situ, and that timing of the notifications is critical. It was indicated by the participants, who noticed a notification shortly before checking out, that users should be notified just-in-time, which the majority of the participants described to be prior to the decision-making process. That is, before or upon entering a

supermarket. This finding is consistent with a proposition on the design of digital interventions related to human intervention research, by Kraft et al, which suggests that: "*Digital interventions should offer instant, just-in-time therapy in order to prevent relapse due to sudden spikes in relapse proneness*" [12].

The findings present issues with current smartphone technology in determining when users are in-situ. This includes external factors, such as blocking of location services when inside buildings and imprecision of location services, as well as internal factors, such as avoiding significant power drainage and annoyances. Associated with these issues, the findings presented issues on timing and awareness of notifications, such that notifications are received and noticed just-in-time. An example of currently existing alternative could be iBeacons, that are defined by Apple Inc as devices that can notify nearby iOS devices of their proximity. The iBeacons are inexpensive, have low power consumption, and are optimized for indoor positioning. Interesting opportunities arise with the introduction of new indoor location services that could be relevant in future work.

With regards to the notifications most often going unnoticed, the findings suggest that current smartphone technology is not optimal for consistent exposure of information in-situ. While the current smartphone technology is not regarded as completely ineffective, information exposure from other approaches are recommended for a majority of the participants. Comparatively, the lambent shopping handle was deployed to the participants in-situ for the entirety of their shopping session and a significant persuasive effect was indicated [10]. Emergent wearable and ubiquitous technology such as smartwatches and activity trackers could provide additional opportunities for exposure. While no single solution is likely optimal, an interesting opportunity for future work is to explore options for combining approaches of in-situ, persuasive technologies.

Context and Decision-making

A preference for using the application out of context, usually at home, was indicated in the findings. While the application was primarily used out of context, it was still indicated that it had reflective properties that affected some participants in their subsequent shopping sessions. Shopping lists were found to be frequently used by 45.5% of the participants, which is slightly to significantly lower than similar research by Ganglbauer et al. [7] and Thomas et al. [24], at approximately 50% and 67%, respectively. This can be explained by the comparatively small number of participants in Food4Thought (11 versus 262 in [24]). Additionally, the findings show that impulsive purchases are common among the participants, which is consistent with previous research [7, 24]. This suggests that some decisions on which products to purchase are made in-situ, and thus there is a possibility to persuade in-situ. A reminder that raises the participants awareness of how they align with their dietary goals could be what makes the difference between a healthy and an unhealthy choice, as was the case for five of the eleven participants.

An interesting and surprising finding was that most of the participants, who described making a purchase based on the information they were presented in the application, later denied having changed their shopping habits. This suggests that the participants were unaware of the persuasive influence of the information, and thus that the application had a nudging effect on some participants. Onwards, I propose that more research is to be conducted on technology-assisted nudging in-situ, as well as on reflective persuasion in-situ in comparison to out of context.

Interactivity and Information

The non-suggestive and reflective approach of Food4Thought was well-accepted by the participants, which is consistent with the findings of Baumer et al. on VERA [2]. This suggests that approaches that do not decide for the user what to do, but encourages the user to reflect and come to their own conclusions, can be effective. One of the limitations pointed out by Baumer et al. was a decline in self-reporting over time, likely due to the novelty effect. While Food4Thought does not have self-reporting and no drop-off in application launches was observed, a study period of five weeks is not sufficient to suggest that a novelty effect is not present. For future work, an obvious improvement to the Food4Thought approach would be to conduct a study for a period of time long enough to reject the influence of a novelty effect.

The findings indicate the importance of tailoring, with several participants requesting to set their own dietary goals or specific food groups to track in the application. The importance of tailoring has been pointed out several times in previous research [3, 11, 25] and is well-established. Surprisingly, many of the participants were unable to correctly describe the properties of the Danish food pyramid although all participants claimed to be familiar with it prior to the study. Not surprisingly this suggest that, for a purely informative interface to effectively persuade, it should be tailored to needs of the user and omit any information that is unwanted or that might confuse the user. Some participants wanted to experience more interactive features in the application, and while some approaches have already explored interactive features of ubiquitous devices in-situ [10, 22] more research is needed to explore which features might be feasible in the long term.

Persuasiveness and Habit Change

That 45% of the participants made a purchase based on the information provided by the application suggests behavior change in the participants in the context of shopping habits. Awareness was raised among most of the participants, while some were even surprised by the presented information. While no single approach will be optimal for all users, the approach of Food4Thought is promising. It is arguable whether more features or interactivity would have been more effective. It is difficult to compare Food4Thought with similar approaches, that use applications that are more feature-rich and facilitate more interactivity [10, 22], since their findings do not describe the effectiveness of their approaches with concrete numbers, e.g. the number of participants who changed habits during the study. I propose that future work should

present such findings. While applications that are feature-rich and facilitate a high level of interactivity might be more interesting for the users, previous research points out the importance of retaining simplicity in the approach [18, 19, 20].

CONCLUSION

With the prevalence of overweight and obesity in people, research on intervention design is as important as ever. Food4Thought is not a final solution to this epidemic, but it does pave the way for future research within the field of persuasive technologies. The suggested approach was deployed to the field in the form of a smartphone application that was used by eleven participants for three to five weeks. The application notified the participants when entering a supermarket to get an overview of their dietary habits. The participants could then open the application from the notification or at home, to get a quick overview of how their shopping habits related to the Danish food pyramid. Location and application activities were recorded and interviews were conducted with all of the participants.

The findings address the three major themes. The first theme was just-in-time and in-situ awareness, in which key findings included the importance of notifying users just-in-time when entering a supermarket, that the application was primarily used out of context at home, and that current smartphone technology is not optimal for notifying users when timing is important. The second theme was reflection and shopping habits, in which key findings included reflections by the users on the information provided by the application, the adoption of shopping lists and proneness of purchasing impulsively among the users, and several occurrences where participants described situations of habit change due to the application while they denied habit change. The third theme was data representation, in which key findings included that the representation of information was found to accurately reflect the shopping habits of most participants, that tailoring of dietary goals was requested due to some participants having their own dietary goals, and that the non-suggestive and non-judgmental approach of the application was well-accepted by most participants.

The findings were related to previous work and some similarities were identified. For example, tailoring was indicated to be of high relevance for persuasive technologies. Additional contributions were made regarding findings on issues with determining when users are in-situ with current smartphone technology, and an alternative was suggested in the form of iBeacons. Suggestions for better notifying and increasing the exposure of information to the users were made, including the use smartwatches and activity trackers when in-situ. Several directions for future research were suggested, including research on context-aware persuasive technologies and how to combine several approaches of persuasive technology in-situ. Finally, a short discussion on simple versus feature-rich applications was presented.

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REFERENCES

1. Android Platform Versions. `https://developer.android.com/about/dashboards/index.html`. [Accessed Mar. 26, 2015].
2. Baumer, E. P. S., Katz, S. J., Freeman, J. E., Adams, P., Gonzales, A. L., Pollak, J., Retelny, D., Niederdeppe, J., Olson, C. M., and Gay, G. K. Prescriptive persuasion and open-ended social awareness: Expanding the design space of mobile health. In *Proc. CSCW12*, ACM (2012), 475–484.
3. Dijkstra, A. Technology adds new principles to persuasive psychology: Evidence from health education. In *Proc. PERSUASIVE06*, Springer-Verlag (2006), 16–26.
4. Fogg, B. J. *Persuasive Technology: Using Computers to Change What We Think and Do*. Morgan Kaufmann, 2002.
5. Fogg, B. J. Creating persuasive technologies: An eight-step design process. In *Proc. PERSUASIVE09*, ACM (2009), 44.
6. *Revidering og Revitalisering af Madpyramiden. Sundhed, Smag og Klima*. Fællesforeningen for Danmarks Brugsforeninger, 2011.
7. Ganglbauer, E., Fitzpatrick, G., and Molzer, G. Creating visibility: Understanding the design space for food waste. In *Proc. MUM12*, ACM (2012), 1–10.
8. Glaser, B. G., and Strauss, A. L. *The Discovery of Grounded Theory: Strategies for Qualitative Research*. Transaction Publishers, 1967.
9. Hamari, J., Koivisto, J., and Pakkanen, T. Do persuasive technologies persuade? - a review of empirical studies. In *Proc. PERSUASIVE14*, Springer (2014), 118–136.
10. Kalnikaitë, V., Rogers, Y., Bird, J., Villar, N., Bachour, K., Payne, S., Todd, P. M., Schöning, J., Krüger, A., and Kreitmayer, S. How to nudge in situ: Designing lambent devices to deliver salient information in supermarkets. In *Proc. UbiComp11*, ACM (2011), 11–20.
11. Kaptein, M., Ruyter, B. D., Markopoulos, P., and Aarts, E. Adaptive Persuasive Systems: A Study of Tailored Persuasive Text Messages to Reduce Snacking. *ACM Transactions on Interactive Intelligent Systems 2*, 10 (2012), 1–25.
12. Kraft, P., Drozd, F., and Olsen, E. Digital therapy: Addressing willpower as part of the cognitive-affective processing system in the service of habit change. In *Proc. PERSUASIVE08*, Springer-Verlag (2008), 177–188.
13. Kvittering.dk. `http://kvittering.dk/`. [Accessed Feb. 18, 2015].

14. Langrial, S., and Oinas-Kukkonen, H. Less fizzy drinks: A multi-method study of persuasive reminders. In *Proc. PERSUASIVE12*, Springer-Verlag (2012), 256–261.

15. Maheshwari, M., Chatterjee, S., and Drew, D. Exploring the persuasiveness of just-in-time motivational messages for obesity management. In *Proc. PERSUASIVE08*, Springer-Verlag (2008), 258–261.

16. 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.

17. Moss, M. Nudged to the Produce Aisle by a Look in the Mirror. `http://www.nytimes.com/2013/08/28/dining/wooing-us-down-the-produce-aisle.html`, 2013. [Accessed Feb. 18, 2015].

18. Orji, R. O., Mandryk, R. L., and Vassileva, J. Towards a data-driven approach to intervention design: A predictive path model of healthy eating determinants. In *Proc. PERSUASIVE12*, Springer-Verlag (2012), 203–214.

19. Orji, R. O., Vassileva, J., and Mandryk, R. L. Modeling gender differences in healthy eating determinants for persuasive intervention design. In *Proc. PERSUASIVE13*, Springer-Verlag (2013), 161–173.

20. 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.

21. Reitberger, W., Spreicer, W., and Fitzpatrick, G. Nutriflect: Reflecting collective shopping behavior and nutrition. In *Proc. CHI14*, ACM (2014), 3309–3318.

22. Reitberger, W., Spreicer, W., and Fitzpatrick, G. Situated and Mobile Displays for Reflection on Shopping and Nutritional Choices. *Personal and Ubiquitous Computing 18* (2014), 1721–1735.

23. Thaler, R. H., and Sunstein, C. R. *Nudge: Improving Decisions About Health, Wealth, and Happiness*. Yale University Press, 2008.

24. Thomas, A., and Garland, R. Grocery Shoppping: List and Non-List Usage. *Marketing Intelligence & Planning 22*, 6 (2004), 623–635.

25. Xu, A., Chomutare, T., and Lyengar, S. Systematic review of behavioral obesity interventions and their persuasive qualities. In *Proc. PERSUASIVE14*, Springer (2014), 291–301.

APPENDIX B

SUMMARY

This report is concerned with persuasive technologies in a health-related context, and explores an approach to persuasive technology research that is focused on the provision of information to users at opportune moments. The aim of the presented approach is to explore how to design persuasive technologies for intervening unhealthy shopping habits of users when they are shopping in a supermarket. In Chapter 1, a brief overview of the field of health-related persuasive technologies is presented, which includes a systematic review of long-term weight loss interventions, motivational factors for healthy eating in intervention design, and several examples of previous work in the field of health-related persuasive technologies.

Chapter 2 presents an abstract of a research paper that documents the approach mentioned above. The paper includes a study in which a prototype application for smartphones was deployed to the field for 11 participants to use for 3 to 5 weeks. Upon entering a supermarket, the participants received a notification suggesting to get an overview of their dietary habits. By touching the notification, the application was opened and the participants were presented with the Danish food pyramid, as well as how their shoppings habits aligned with it. Activity, location, and shopping data was recorded throughout the study, and the study was concluded with an interview with each of the participants. Detailed findings, discussions, and the conclusion are found in the paper in Appendix A.

Inspired by grounded theory, the data was analyzed and a conclusion is presented in the broader context of health-related persuasive technologies in Chapter 3. Included are key findings from the research paper, as well as suggestions for further research. Some of the key findings and suggestions are that:

- Timing is critical in intervention design. Indicatively, the opportune moment to intervene shopping habits is immediately before, or upon entering a supermarket.
  Considerations of temporal factors along with context is suggested for future work on intervention design.
- Current smartphone technology is insufficient for grabbing a user's attention consistently.
  Alternative ubiquitous technologies are suggested to be explored in future work, such as

smartwatches or activity trackers.

- A contradictory denial of influence was observed in most of the participants who described a situation in which a purchase, which suggests a nudging effect.
  Further research on subtle intervention design is suggested.