Simplifying Mobile Phone Food Diaries

Design and Evaluation of a Food Index-Based Nutrition Diary

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***Abstract*— In this paper, we describe the design and evaluation of POND, a Pattern-Oriented Nutrition Diary. POND is a mobile-phone food diary. We used a theory-driven approach to design POND to address a common challenge users report when using food diaries on mobile phones: the amount of effort required to create food entries in relation to the perceived self-benefit of self-monitoring food intake. The design allows users to create food entries either via a traditional database lookup or a streamlined '+1' approach. 24 people used POND to create predefined food entries. We found that people preferred different approaches to creating entries, which reflected their self-reported nutrition concerns. This supports an argument for rethinking traditional approaches to designing food diaries.**

Keywords—mobile health and wellness; theory-driven design; nutrition; self-monitoring;

I. INTRODUCTION

Globally, the incidence of lifestyle diseases such as obesity, diabetes and cardiovascular disease are increasing. One-third (34%) of adults were overweight or obese in 2008 [1]. The prevalence of diabetes for all age groups, worldwide, is expected to rise from 6.4% in 2010 to 7.7% (439 million people) in 2030 [2]. Researchers believe this to be an underestimate. Cardiovascular disease (CVD) is the number one cause of death globally. 17.3 million people died from CVDs in 2008, accounting for about 30% of worldwide deaths [World Health Organization]. Additionally, it is estimated that at least 50% of cancers are preventable by encouraging healthy behaviors and discouraging unhealthy practices. Cancer accounted for 7.6 million deaths in 2008. The estimated number of new cancer cases in 2030 is 21.4 million, with 13.2 million deaths [3].

Researchers believe that a primary cause of obesity is an imbalance of energy intake and expenditure: People eat too many calories while not burning enough calories. While obesity is a risk factor for CVD, diabetes and cancer, it is believed that these diseases are also impacted by the kinds of food people eat. In addition to balancing caloric intake, the American Heart Association recommendations for preventing cardiovascular disease includes consuming a diet rich in fruits and vegetables, choosing whole grain–high fiber foods, limiting saturated fat intake, and reducing consumption of added sugars and alcohol [4]. Similar recommendations are made for preventing diabetes [5].

The field of persuasive technology aims to use computers and technology to persuade or nudge people to change their behavior, in a way that they want to change [6]. Ubiquitous mobile devices such as smartphones have been considered ideal platforms for administering behavior change programs, especially around eating behaviors. In September 2012, the Pew Internet and American Life project reported that 45% of American adults own smartphones [7]. Since smartphones are personal devices people usually keep with or near themselves, they enable *kairos*: providing relevant information and decision support at the time of need. That is, these devices allow people to self-monitor what they eat by providing a means to capture what has already been eaten. It also provides timely support for looking up caloric values for prospective foods. This allows people to make an informed decision about what to eat, before they eat. However, formal research and informal feedback indicates that people have difficulties adhering to the use of mobile-phone food diaries for extended periods of time.

One repeatedly mentioned challenge to using a mobile device for self-monitoring dietary intake is due to finding foods in the database. Keeping track of detailed nutrition information requires finding a specific food in a database. The food can be found either by searching or browsing. Searching for a food requires literacy skills, physical dexterity and visual acuity. A small database provides fewer potential results to sort through, but a lower chance of finding the desired food. Large food databases require more time choosing the best food from a list. The alternative, browsing a hierarchy of food categories, requires nutritional literacy, in addition to more time.

In this paper, we describe user experiences with a food diary that does not require the use of a food database. Food indexes inform the design of the nutrition diary. As we describe in further detail later, food entries can be entered either using a quick, "+1" approach (for a summary entry), or a more traditional database query approach (for a more detailed entry). However, this puts more of a burden on the user to interpret a food in the context of the index.

The contributions of this work are twofold. First, we present the design of a food diary that does not depend on a food database. Second, we report on an initial in-lab usability study

II. RELATED WORK

Related work in the self-monitoring of dietary intake has fallen in three areas: focus on a specific disease population; including dietary intake as part of a larger program including tracking of physical activity; and incorporating strategies to summarize dietary intake.

A. Food Tracking for Special Populations

Siek et al. [8], [9] explored the use of PDA-based self-monitoring of dietary intake by individuals with chronic kidney disease. They examined when people made entries; what challenges they faced; and the use of barcode scanners and voice input to improve the food input process. Mamykina et al [10], [11] explored supporting diabetes patients in managing their dietary intake. Newly diagnosed diabetics usually go through a period of changing their dietary behaviors. MAHI is a mobile phone application that supports users in capturing and documenting eating episodes throughout the day. The records can then be reviewed later, encouraging reflection on the individual's behavior and choices. This can be characterized as a quick-capture with a strong emphasis on post-hoc analysis. The user populations in the Siek and Mamykina work have well-defined constraints on dietary intake. Individuals who need to change their nutrition behaviors to treat a disease may be more motivated to use technology to support self-monitoring than individuals focused on preventing disease.

B. *Combined Food and Activity Tracking*

Tsai et al. [12] investigated the use and timing of reminders on use of a mobile-phone-based combined physical activity and nutrition diary. They found that reminders did help, but also reported challenges around their nutrition diary. The food database contained 750 items and used a naïve search algorithm for querying the database. Denning et al. [13] took a similar approach with BALANCE, but using an external sensor unit to automatically detect physical activity to aid in the monitoring process. Users still found it difficult to self-monitor food intake with automated physical activity monitoring and an extensive food database.

C. *Tracking Summarized Measures*

In contrast to tracking detailed caloric intake and expenditure data, the Wellness Diary [14] allowed users to monitor many different health and wellness indicators. These include quality of food intake, amount of physical activity, sleep, stress levels, and amount of time spent at work for the day. In regards to the self-monitoring of dietary intake, eating episodes were captured by triage: a meal could be rated as “healthy”, “not healthy” or “unknown”. This study provides evidence that suggests even cursory attention to monitoring food intake can have impact on eating behaviors. This is consistent with work by Burke et al. [15] who participants in a behavioral weight-loss program and found varying levels of engagement with the self-monitoring process. Some participants were highly engaged, while others were nominally followed the procedure or were inconsistent. It is unclear whether this characterization is due to internal or external factors. However, a self-monitoring tool that allows for varying levels of engagement could support a wider range of users.

Andrew et al. [16] compared user performance and preference of three different food diaries: a traditional, database-lookup diary; a diary tracking only food groups (least detail); and a diary tracking food groups and some nutrients. They found that in a lab study, users made the fewest errors with the traditional food diary, but took the most time. The food group diary took the least time with an error rate similar to the traditional diary. However, users felt the food group diary was over-simplified. The reduced time and errors were not worth the loss of detail. Users preferred either the traditional approach or the food groups plus nutrients approach.

III. Background

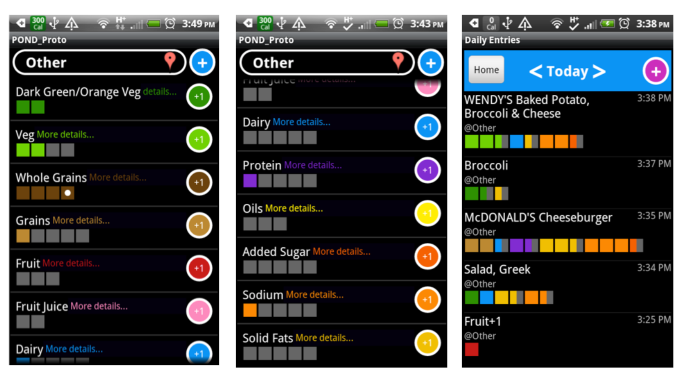
The Healthy Eating Index (HEI) [17] is a food index based on the USDA Dietary Guidelines for Americans [US Health and Human Services and US Department of Agriculture, 2005a]. The original HEI was developed in 1995 and revised in 2006 to reflect the 2005 Dietary Guidelines. The HEI is a score based system, with a diet closely reflecting the 2005 Dietary Guidelines earning a score of 100 points. Twelve components contribute to the overall score: Grains (whole, total); Vegetables (dark green and orange, total); Fruit (whole, total including 100% juice); Meat, Bean and Eggs; Dairy; Oils; Sodium; calories from Solid Fats, Added Sugars and Alcohol; and Saturated Fat. Some components are attainment components, where the score goes up as more of that food is eaten. Attainment components reflect that most Americans do not eat enough of these foods (such as whole grains and vegetables). Other components are to be moderated. For these components, the score decreases as more is consumed. These components (such as calories from Solid Fats, Alcohol and Added Sugars) reflect things most Americans consume too much of. The attainment components for HEI contain primarily food groups. All of the moderation components are considered nutrients. The calculation for each point depends on the individual daily recommended caloric intake.

IV. The Design of POND

Here, we present the design of POND, a Pattern-Oriented Nutrition Diary, to explore the value of reducing the amount of time and effort to capture an eating episode while also reducing the amount of detail that is captured. The primary goal informing the design of the POND app was to minimize the amount of time it took to make an entry. Preference was given to design decisions that were consistent with minimizing initial food entry creation.

POND was designed to reflect the HEI. It allows users to focus on monitoring the HEI components of the food that they eat. Users enter food eaten by counting the contribution to each of the 12 HEI components, rather than a more traditional approach of looking up a food in a database. Users customize the interface to include and track all components, or to hide components they are less interested in. Early user testing showed that users sometimes felt uncomfortable without a reference database, especially for combination or prepared foods, so this feature was added. The database used the NutritionistPro Knowledge Base, which contained about 42,000 foods.

Figure 1 (a & b) shows the screen the user sees when they launch POND. This screen was designed to prioritize quick entry and quick analysis of the current progress toward goals for the day. Each row represents a recommendation from the HEI described above. Dark gray boxes indicate the current daily goal for that component. A colored box indicates how many portions of that component have been consumed. A colored block with a white dot indicates that the user has consumed more than the goal number of blocks. The use of a white dot in the block was chosen in order to provide non-judgmental feedback about the number of servings consumed. Users touch the +1 buttons on the right side of the screen to quickly indicate a portion eaten, or long-press the +1



(a) (b) (c)

Figure 1 The POND interface. The main screen includes a row for each component (a and b). The “Today” screen (c) shows a list of foods that have been entered on this day.

buttons to indicate a ½ portion eaten. The colored links next to the component name expand to show more detailed information about that component, including how much to count as one block. This information was adapted from the USDA 2010 Dietary Guidelines.

Features not described in this paper include looking up food in the database, creating custom food entries, reviewing daily entries, editing entries, changing goals and reviewing weekly progress.

V. EVALUATION

We performed a two-phase evaluation of POND. The first phase is an in-lab study where participants created specific food entries. The goal was to collect usage data we could compare across users. In the second phase, the participants used POND in situ for three weeks. This allowed us to understand how POND adapted to real world eating contexts. This paper reports on just the first phase.

This evaluation included 24 participants, 18 female and 6 male. Ages ranged from 21-64, and occupations varied. All participants reported using their cell phone several times a day, and all except 1 reported entering text on their cell phones several times a day (the remaining one entered text on their cell phones 1-2 times daily). 19 participants reported that one of their health goals is to ``Eat better''. 17 reported themselves as "very" or "fairly" knowledgeable about food and nutrition, while 5 as "not so" knowledgeable or "fairly uneducated" about food and nutrition.

Participants were recruited via craigslist ad, multiple community email lists, and physical posters on community bulletin boards. The recruitment advertisement asked for people who were able and willing to journal their food for three weeks. Participants were compensated $125 for their participation in both phases of the study. Participants self-reported that they had no medical concerns that impacted their food choices and owned their own Android devices.

The study consisted of 4 conditions with 5 tasks in each condition. The conditions varied in the number of components the user could use to create a food entry. Conditions were Small (2 components), Medium (5 components), Big (9 components) and Full (all components). Components were chosen randomly without replacement. Order of conditions for each participant was counterbalanced. Each condition represented roughly 1 day of food intake. Each task represented the content of a single meal. Each food name and amount for a single task was printed on a card. Tasks were presented one at a time. At the end of each condition, participants completed a questionnaire that included TLX measures.

VI. RESULTS

In the interest of space, we focus our discussion on three results. *Entry strategy* characterizes whether tasks were completed using only the +1 buttons, only the food lookup feature, or a combination. *Search terms* reveals what foods participants looked up in the database rather than entering directly via the +1 buttons. *Likes and dislikes* is participant self-report of what they liked and did not like about each condition.

A. Entry strategy

We were interested in when users made the decision to use the +1 buttons or the lookup feature to enter a task. Participants reflected one of three strategy approaches. Participants concerned with an *overview* used the +1 buttons primarily, for all tasks. 10 participants used the +1 buttons exclusively (never using the lookup feature), and three other participants used the +1 buttons primarily. Other participants (4) were concerned with a *detailed* record, using the lookup feature primarily. The last 10 participants reflected an *opportunistic* approach, choosing to use the +1 strategy as often as the lookup strategy.

B. Search terms

Overall, the 24 participants made 650 queries from 273 unique phrases. 130 search terms were used by more than one person. All phrases with 8 or more queries are listed in Table 1. Of these 13 queries, 3 represent foods that most likely fit into a single category (egg, salad and milk). It is possible that the salad query was used to find a "Caesar salad" entry (salad greens plus dressing and croutons), rather than simply salad greens, which could be counted with just one food group. The other 10 most common queries (not listed) represent foods that are primarily packaged and prepared. The mean length of query is 13.6 characters. 6 search terms were between 36 and 40 characters, with as many as 7 words ("bag n season pork chop seasoning mix").

C. Likes and Dislikes

Qualitative feedback about the Small condition (2 components) indicated that some people liked that it was so short, therefore very quick and easy to enter, and *"it was trying to just keep track of my best and worst food choices"*. Others felt it was too limiting *"I wanted to put all of the food I ate into categories, not just some of it"*.

Feedback about the Medium (5 components) and Large (9 components) conditions was mixed. While there were fewer components than the large condition, it was more *"mentally taxing"* because participants "*had to think more about whether a food contained parts of the specified categories"*. This feedback is possibly due to randomly choosing which components were presented in each condition. The random choices may not reflect meaningful components for the user.

Finally, participants liked having all the categories. They reported that it made them more informed and ensured they were accounting for all components. Feedback suggested that it was satisfying to have a way to count all foods. When all of the components are present, all food (except, in this study, alcohol) can be counted.

TABLE 1. COMMON SEARCH TERMS.

Search term	Number of people who used it
doritos	11
baking chocolate	10
egg	9
wheat thins	9
fiber one	9
pepperoni	9
starbucks	8
mashed potatoes	8
wheat crackers	8
don miguel	8
le gout	8
salad	8
milk	8

VII. Discussion

The goal of the in-lab portion of the POND evaluation was to characterize how people used the diary to create known food entries. We reported the strategy participants used to make an entry, the search terms used for known foods, and the things participants liked and disliked.

Participants were split on how much to use the +1 buttons rather than the lookup feature for creating food entries. The randomization of the components to the conditions could impact the choices that participants made in regards to using the +1 versus lookup. The Full condition (which contained all components) are comparable across all participants, but in the Small and Medium conditions, it is possible that the components contain either just easy food groups (Fruit, Veggies) or all nutrients (Sodium, Sugar), which are known to be more challenging to count, and people report using the lookup feature for them. A question addressed in the follow-on study is whether participants continued their entry strategy *in situ,* and whether the strategy changed as participants became more familiar with how to count foods in terms of the components.

Reviewing the most common search results indicates that participants are searching for unfamiliar, processed foods that are challenging to identify components of. These foods also tend to be higher in sodium and solid fats, which are difficult to estimate without looking up. This is consistent with our initial usage expectations. We expect the *in situ* study to provide insight as to whether participants learn about the components of different foods, and how it impacts their ability to track those foods with the +1 buttons rather than searching the database.

We initially believed that the component-based design of POND could support user customization and prioritization of food components the user is interested in. This could further streamline the entry process: fewer components to count takes less time to enter. However, the randomly chosen components in this study appeared to confuse participants more than help. A question to address in future work is whether participants find this ability to customize helpful *in situ*. Another question is whether users actually customize the interface, or simply ignore components they are not interested in.

VIII. Conclusion

The work presented in this paper represents a preliminary evaluation of an index-based nutrition diary. The evaluation suggests that different users have varying desire for nutrition detail. Providing an ability to vary the amount of detail, and therefore the amount of effort required to capture nutrition details, could help users sustain self-monitoring behaviors.

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