

Rethinking the Mobile Food Journal: Exploring Opportunities for Lightweight Photo-Based Capture

Felicia Cordeiro¹, Elizabeth Bales^{1,2}, Erin Cherry³, James Fogarty¹

¹ Computer Science & Engineering

² Human Centered Design & Engineering

DUB Group, University of Washington

{felicia0, lizbales, jfogarty}@cs.washington.edu

³ Computer Science

University of Rochester

erinc@cs.rochester.edu

ABSTRACT

Food choices are among the most frequent and important health decisions in everyday life, but remain notoriously difficult to capture. This work examines opportunities for lightweight photo-based capture in mobile food journals. We first report on a survey of 257 people, examining how they define healthy eating, their experiences and challenges with existing food journaling methods, and their ability to interpret nutritional information that can be captured in a food journal. We then report on interviews and a field study with 27 participants using a lightweight, photo-based food journal for between 4 to 8 weeks. We discuss mismatches between motivations and current designs, challenges of current approaches to food journaling, and opportunities for photos as an alternative to the pervasive but often inappropriate emphasis on quantitative tracking in mobile food journals.

Author Keywords

Personal Informatics; Self-Tracking; Food Journals; Photos.

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI).

INTRODUCTION

Food choices are among the most frequent and important health decisions in everyday life, yet it remains notoriously difficult to understand our food choices. People eat in many different contexts and have widely varying motivations and constraints on food. Being mindful of the quality and quantity of food choices is a crucial component of a healthy life [35,36], and food journals can be effective for monitoring food intake [8,15]. The implications of food also go beyond health, as food is central to our daily experiences and our relationship with food varies according to personal contexts and goals [14]. But food journals impose high burdens that detract from their potential benefit [11,12]. Effective food journaling is thus a grand challenge for personal informatics.

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than ACM must be honored. Abstracting with credit is permitted. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee.

Request permissions from Permissions@acm.org.

CHI 2015, April 18 - 23 2015, Seoul, Republic of Korea

Copyright 2015 ACM 978-1-4503-3145-6/15/04\$15.00

<http://dx.doi.org/10.1145/2702123.2702154>

Figure 1. An entry in our lightweight photo-based food journal. No calorie or nutrition information is shown, as the journal instead logs meal enjoyment, location context, and social context.

Automated sensing has proven powerful in some domains of human activity, but remains out of reach for food despite recent advances [1,3,18,27,29,32,38]. It is also unclear whether automation is desirable, as it may undermine in-the-moment awareness created by food journaling [36]. Some existing methods involve taking photos of food as an intermediate step toward collecting underlying nutritional information [18,27,38]. We step further back, asking what people want to capture about food and what value photos themselves might provide in a lightweight food journal.

Our work examines lightweight photo-based capture and reflection, reconsidering the common assumption that a quantitative approach is required. We first present a survey examining how people define healthy eating, experiences and challenges with existing food journals, and how people interpret the healthiness of food presented as either photos or nutrition labels. We then present interviews and field deployments of a lightweight, photo-based mobile food journal. A total of 27 people with varying food goals from two distinct trials use our application to journal for between 4 to 8 weeks. We explore reactions to a design focused on food photos in lieu of nutritional information and examine the value of food photos with regard to their goals. Finally, we discuss our results in the context of rethinking challenges and opportunities in the design of mobile food journals.

The specific contributions of our work include:

- Examination of how people define healthy eating, their experiences and challenges with food journaling, and their interpretation of nutritional information that can be captured in a journal. This includes surveying 257 people to define healthy eating and to rate the healthiness of foods presented as either photos or nutrition labels.
- A field study examining a lightweight photo-based food journal. Specifically, we build and deploy DECAF with 27 people with varying food goals from two distinct trials, each for between 4 to 8 weeks. We examine the challenges participants encounter in journaling relative to their prior methods, the value they find in photos, and differences according to their food goals.
- Discussion of opportunities for lightweight photo-based capture and reflection in mobile food journals. In contrast to quantitative designs, our results suggest an opportunity for qualitative capture and reflection to help support the diversity of goals that people bring to food journaling.

RELATED WORK

We review six areas of related work: benefits, traditional methods, challenges, automation, photos and alternative representations, and alternative views on food journals.

Benefits of Food Journaling

Food journaling can provide benefit across many areas of health. Hollis et al. found weight-loss patients who kept regular food journals lost twice as much weight as patients who kept no records [16]. Reflective analysis of daily food intake and symptom progression is critical in diabetes management, thus motivating food journals and more comprehensive health monitoring systems that help scaffold understanding and interpreting collected data [21,22]. Similarly, food journals and elimination diets are critical tools in identifying and managing food allergies [15,30]. In addition to creating a record, journaling can encourage healthier choices by increasing in-the-moment awareness. Prior studies have found increased mindfulness encouraged journalers to avoid consuming unhealthy foods [17,36].

Traditional Food Journaling Methods

Early methods used lengthy interviews and questionnaires to understand patient eating habits [24]. Recall and paper diaries remain popular in the medical community [7], but mobile devices have become powerful journaling tools. Early research proposed using mobile devices to provide real-time feedback on daily calorie budgets [33]. Outside the medical community, many common commercial phone applications now support using food databases to journal calories and other nutritional information relative to a daily budget (e.g., MyFitnessPal, Lose It!). A person journals food by searching for each component of a meal in the database and then entering portion information. Many applications also allow storing custom recipes, shortcuts for commonly eaten foods, or using barcode scanners to quickly enter packaged foods. Others strive to simplify journaling using a point system (e.g., Weight Watchers).

Challenges of Food Journaling

The high level of engagement required for food journaling can quickly lead to fatigue and reduced compliance [4,12]. Choe et al. found self-trackers across a variety of domains encounter key difficulties in tracking too much information or information that is irrelevant to their goals, contributing to fatigue and abandonment [10]. In research reviewed later in this paper, Cordeiro et al. examine barriers and negative nudges in current food journals [11]. Another important problem is data hoarding, the practice of completing many delayed entries at once [31]. Our interest in photo-based journals is partially motivated by a desire to examine how photo-based capture might reduce fatigue, but also that temptation to hoard might be reduced because a person can only take a photo of food before or during its consumption.

An additional food journaling challenge is the accuracy of journaled nutrition information. Journaled calories can be inaccurate by 20% to 50% [19,20], due to difficulty finding appropriate entries in food databases, unreliable entries in those databases, and difficulty estimating portions [11,35]. Inaccurate estimates are problematic for people relying on them to make decisions relative to a daily budget, especially when combined with errors in estimating calorie expenditure. This plays a role in a popular backlash against gaining weight while following the guidance of popular fitness devices [34].

Automating Food Journals

Researchers have investigated automating food journaling by detecting chewing sounds [1,29] or scanning grocery receipts [23]. Others have proposed automatically capturing meal photos using wearable devices, such as SenseCams [3,32]. In addition to automatic image capture, there have been several attempts to automate nutrition entry, including crowdsourcing nutrient estimates [27] and using computer vision to recognize foods [18,38]. But visually similar foods can have vastly different nutritional profiles (e.g., due to the presence of condiments not visible in a photo, according to whether the food is homemade or processed). As previously noted, full automation may also undermine the mindfulness benefits of food journaling [36]. We designed our photo-based journal to lower the burden of journaling while still requiring active involvement in data capture.

Photos and Alternative Representations in Food Journals

Prior work has proposed food photos to simplify journaling. Photos can be used for estimating nutrient content and portion sizes [6,26] or directly for reflection [5,13]. Zepeda and Deal compare food journaling with paper versus a camera, finding in-the-moment photos increase awareness of unhealthy eating [37]. Frost and Smith develop a system to support diabetes patients in taking and viewing photos in conjunction with visualizations of blood glucose levels, including but not limited to food photos [13]. They report some participants observed trends between foods consumed and blood glucose. Research has also explored other representations for food journals, often intended to simplify capture. Andrew et al.'s POND journaled according to food components (e.g., grains, vegetables, sodium, solid fats,

added sugar) and allowed circumventing database search by directly journaling components [2]. Mattila et al. present a multi-dimensional wellness diary that emphasized minimal entry designed for long-term self-tracking, finding sustained usage they argue contrasts with what could be expected of more burdensome journals [25]. We build upon these prior results to examine direct use of photos for lightweight capture and reflection in support of a variety of food-related goals, focusing on contrasts to challenges reported by participants with prior journaling methods.

Alternative Views on Journaling

Many food journals are designed with a focus on persuasion and behavior change, but research has critiqued this as a limiting view. Purpura et al. present Fit4Life, a fictional persuasive system promoting healthy behavior and ideal weight, then use it to discuss issues of control and coercion in self-tracking [28]. Baumer et al. similarly argue a focus on prescriptive persuasion is limiting, then create VERA to explore open-ended social awareness as an alternative approach [5]. More focused on food, Grimes and Harper critique what they term “corrective technology” and suggest “celebratory technology” as an alternative, noting that food journaling can be used as a reflective task to capture positive aspects related to food, such as time spent with family and friends, moments of creativity, and meaningful exchanges [14]. We build on these perspectives of personal empowerment, in that our focus on qualitative capture and reflection in a photo-based journal allows people to interpret their journal according to their personal goals.

FOOD JOURNALING SURVEY

We conducted a survey of 257 people (162 female) of which 141 had current or past food journaling experience. Respondents were recruited from university and local mailing lists, Facebook groups, and Fitbit and MyFitnessPal forums. The median age was 30 years (range: 19 to 70). The majority of respondents (64%) had Body Mass Index (BMI) scores within the normal range, with 10 people opting out of providing height and weight information. Table 1 shows additional survey participant demographics.

All survey respondents were first asked “*What does healthy eating look like to you?*” They were then asked to rate the healthiness of 9 foods on a scale of 1 (Very Unhealthy) to 7 (Very Healthy), using food images or the corresponding nutrition labels. The images and nutrition labels represented the same foods but were presented in a random order. The foods correspond to a range of nutritional profiles, selected to fall into four groups: (1) foods that look healthy in a photo, but unhealthy on a nutritional label (avocado, salmon, mixed nuts), (2) foods that look unhealthy in a photo, but look healthy on a nutritional label (waffles, mac and cheese), (3) foods that look healthy on both (apple, cucumber), and (4) foods that look unhealthy on both (burger, cake). The nutrition labels presented the nutritional information for a single serving. Figure 3 shows a sample food photo and corresponding nutritional label. We note that food is complex, and the medical community has no

	Past Journalers	Current Journalers
Gender	69 Female, 25 Male	36 Female, 11 Male
Age	M: 34, SD: 9.5, Min/Max: 21/70	M: 34, SD: 11.7, Min/Max: 19/64
BMI	M: 25, SD: 4.6, Min/Max: 17/43	M: 28, SD: 7, Min/Max: 19/53
Length Journaling	Median: 2-3 months, Min/Max: 1 week / 2+ years	Median: 7-12 months, Min/Max: 1 week / 2+ years
Benefits of Journaling	I feel better about myself (17), it helps me lose weight (35), it makes me think about my eating decisions (75), it helps me find patterns (42), it helps me have a record (44)	I feel better about myself (14), it helps me lose weight (34), it makes me think about my eating decisions (40), it helps me find patterns (23), it helps me have a record (22)
Methods of Journaling	Paper (45), MyFitnessPal (18), Weight Watchers (13), Other Mobile (22), Desktop / Website (19), Fitbit (2), Other (18)	Paper (2), MyFitnessPal (25), Weight Watchers (3), Other Mobile (7), Desktop / Website (4), Fitbit (7), Other (2)
Accuracy of Journal (Remember to log...)	all of their food (30), most of their food (45), 75% of their food (14), 50% of their food (3), mostly forgot (1)	all of their food (20), most of their food (16), 75% of their food (8), 50% of their food (1), 25% of their food (1), mostly forgot (1)
When Meals are Logged	after eating (48), end of the day (19), when remember (8), before eating (4), other (6)	after eating (21), when remember (6), before eating (12), other (4)
Method of Calorie Journaling	64 used calorie journaling: 37 used databases, 31 used the internet, 25 used nutrition labels, 18 estimated on their own, 8 used a book or other resource	40 used calorie journaling: 28 use databases, 19 use the internet, 23 use nutrition labels, 2 estimate on their own, 3 use a book or other resource

Table 1. We surveyed current and past journalers to examine their perspectives on healthy eating and their experiences with current food journaling methods.

single objective measure for rating food healthiness [9]. This survey targets respondent *perceptions* of healthiness.

Past and current journalers were further asked to respond to questions about their goals for food journaling, their journaling methods, the benefits received from journaling, as well as experiences and difficulties in journaling. Respondents who no longer journaled were additionally asked questions targeting their reasons for stopping. We used open coding techniques on open-ended questions to extract themes and gain an understanding of trends.

SURVEY RESULTS

We present survey results in four sections: healthy eating as defined by respondents, food journaling barriers, when and why past journalers stop journaling, and comparing healthiness ratings between photos and nutrition labels. Additional analysis of responses regarding current and past food journaling practices is available in [11], with this paper focusing on their relevance to photo-based food journaling.

What Does Healthy Eating Look Like

Responses to “*What does healthy eating look like to you?*” identified a variety of perspectives, summarized in Figure 2. Responses include consensus around several themes: eating more vegetables (77%), more fruit (53%), or more protein (33%), maintaining a balanced diet (29%), and avoiding processed foods (29%).

In contrast, we note only 24 (9%) respondents mentioned calories. Calories are probably the most pervasive metric for weight-loss and nutrition journaling, but reducing food to such a single numeric value often loses the dimensions respondents said were important (e.g., eating more vegetables, eating more fruit, having a balanced diet,

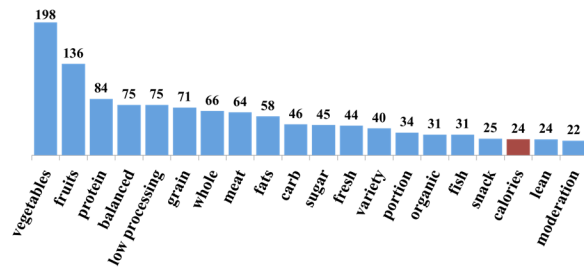


Figure 2. The 20 most frequent survey responses to “What does healthy eating look like to you?” Respondents identify a variety of themes, in contrast to a focus on calories in many current food journaling applications.

having a low processed diet). This suggests a mismatch between how people define healthy eating versus the information highlighted in many current food journals.

Food Journaling Challenges

The most cited reason for not journaling was forgetting, with 54% of respondents having missed an entry for this reason. However, forgetting was far from the only reason respondents did not journal. Even when they remembered they should journal, 40% reported choosing not to journal a food that was too difficult to enter. Additional reasons for not journaling included not knowing what was in a meal (40%) or social contexts (20%), such as not wanting to journal in front of friends. This shows that forgetting is not the only challenge in current approaches to capture, thus suggesting opportunities for new designs. But 13% of respondents further reported they intentionally avoided journaling when they ate something unhealthy or did not want to record exceeding a calorie budget: “Sometimes I feel like not logging things because I know it’s really unhealthy. =(” (P117). This is problematic in that deciding against capture undermines later reflection or analysis.

Although respondents reported packaged food and fast food were the easiest to journal with their prior tools, that conflicted with how they defined healthy eating (e.g., to eat less processed foods). Most journaling applications allow adding entries for foods not found in a database, but many respondents found this tedious. Some even reported avoiding food that was hard to track, instead turning to packaged food: “They weren’t on the list. I just avoided eating things that were hard to log.” (SP132). This exposes a concern that journaling can artificially limit food choices by incentivizing foods that are easier to track, even though those foods may not support journaler goals. Cordeiro et al. discuss this as a negative nudge in current journals [11].

When and Why Did Past Journalers Stop

Of 141 respondents with prior food journaling experience, 94 no longer kept a food journal. Their most common method was paper (48%), and they reported keeping a journal for a median of between 2 to 3 months. In contrast, current journalers primarily used technology (98%) and reported journaling for a median of 7 to 12 months. This suggests technology-simplified journaling is supporting longer-term journaling. The most commonly stated reason

for stopping was reduced value over time (37%), either because a new habit was established or a goal was reached. Other reasons included journaling requiring too much effort (25%), being too time consuming (16%), and a loss of motivation (10%). Reasons for stopping were often complex with many factors contributing to the decision.

SP27 was representative of encountering multiple barriers and ultimately deciding to abandon journaling: “It was too time consuming and tedious. I also did not know what to enter if I ate out, so I often did not enter data and that compounded. I also felt embarrassed to do it in front of friends so I stopped. It seemed like more work than it was worth.” We further discuss these general challenges to food journaling in Cordeiro et al. [11], with the remainder of this paper focusing on our lightweight photo-based food journal.

Comparing Food Representations

We hypothesized food representation impacts perception of healthiness. We tested this by asking respondents to rate 9 food photos and their corresponding nutrition labels on a scale of 1 (Very Unhealthy) to 7 (Very Healthy). We also asked which representation made it easier to determine.

When asked which representation made it easier to determine healthiness, 46% of respondents selected photos, 22% selected nutrition labels, and the remainder had no preference. For participants that preferred photos, many expressed having an image in their mind of what healthy and unhealthy looked like, but knowing less about nutritional contents: “I think I have roughly accurate pictures in my mind of what a healthy vs. not healthy food looks like, but I’m realizing I don’t really know the nutritional makeup of any of these things with any sort of decent accuracy” (SP190). Many respondents that preferred photos also reported advantages of photos over nutrition labels, such as being able to determine portion sizes, the method of cooking, or whether food was processed: “I have a hard time understanding size, and whether or not the food is heavily processed, which pictures convey” (SP170) and “photographs reveal quality” (SP179). The respondents that preferred nutritional labels generally worried about pictures hiding condiments and wanted precision in calorie counts, two points we revisit in examining field study responses.

To further examine respondent interpretation of food representations, we calculated the skewness of healthiness rankings for each food in each representation, using the adjusted Fisher-Pearson standardized moment coefficient with a 0.9 cutoff. The skew allowed us to determine the general trend in how respondents perceived the healthiness of each food and compare that trend across representation. The results of these comparisons fell into three groups, shown in Figure 3. We found foods that (1) had the same skew in both representations (e.g., hamburgers rated unhealthy in both, cucumbers rated healthy in both), (2) foods with skew in the photo but no skew in the label (e.g., salmon rated healthy in the photo, but had no skew in labels), and (3) opposing skew (e.g., mixed nuts rated healthy

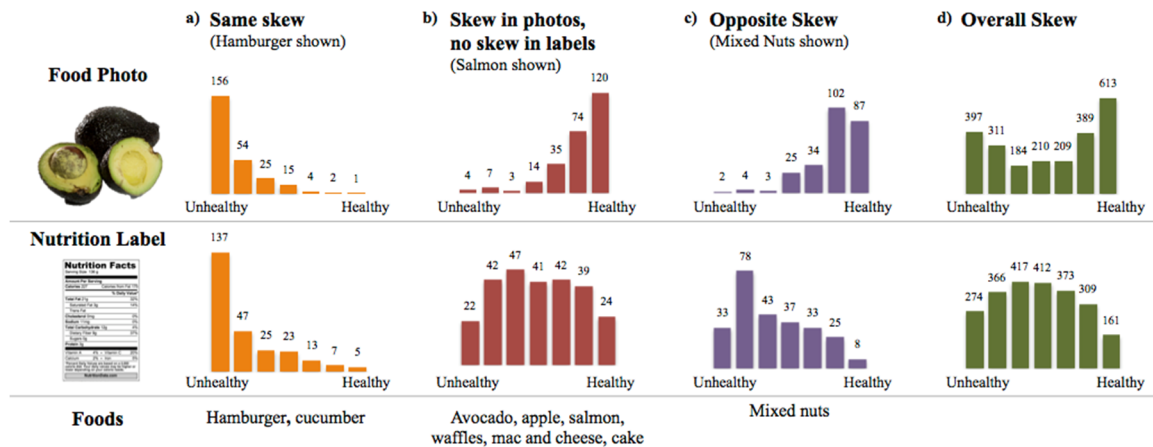


Figure 3. Respondents rated the healthiness of the same foods represented using Food Photos or Nutrition Labels. We found a) foods with agreement in skew in both representations, b) foods with skew in only the photo representation, c) foods with opposing skews in the representations, and d) more extreme ratings for Food Photos.

in the photo, but unhealthy in labels). Consistent with our finding that calories are not primary in how many define healthy eating, these differences in skew show that low-level nutritional information often does not correspond with how people consider food healthiness.

In the photo representation, all foods had either a positive or negative skew. In contrast, only three foods had skew in the nutrition labels representation. Figure 3d illustrates the combined respondent ratings across all foods. Respondents overall ranked photos toward extremes (i.e., “very healthy” or “very unhealthy”). Nutrition labels for the same foods received a broader range of scores. We tested whether photos yield more extreme ratings using a chi-squared test, bucketing ratings in (1, 2, 6, 7) as *extreme* and ratings in (3, 4, 5) as *neutral*. Respondents were significantly more likely to give food an *extreme* rating with a photo representation than with a nutritional label representation $\chi^2(1, 4626) \approx 624, p < .001$. Food photos thus allowed respondents to develop a stronger opinion of the healthiness of foods, while nutrition labels left them unsure. This supports our prior discussion of respondent statements they prefer photos because they understand healthiness but are often unsure how to interpret nutritional information.

FIELD STUDY OF A LIGHTWEIGHT FOOD JOURNAL

Our survey reveals challenges in food journal design, mismatches between journals versus how people define healthy eating, and opportunities for photo-based capture. Because of the survey method, responses were based in recollections and hypothetical foods. We complement this with a field study examining photo-based journaling with the food that journalers encounter in their everyday lives.

We conducted our field study by developing a food journal organized around photos and does not include calories or nutrition information. We deployed it with 27 people to examine: (1) the impact of photo-based capture on food journaling challenges, (2) what value photos provide absent nutritional details, and (3) how journaling challenges and the value of photos vary according to journaler goals.

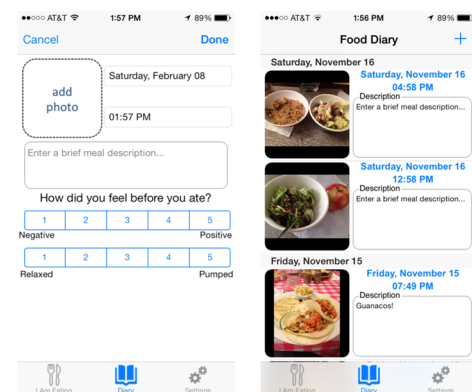


Figure 4. The DECAF mobile interface, showing a blank journal entry (left) and a scrolling journal view (right).

The DECAF Food Journal

We conduct our field study using a lightweight, photo-based journal, DECAF (*Diary of Emotion, Context, And Food*). It consists of two components: (1) a mobile application for easy food capture, and (2) a website for providing details and reflection. At the time of eating, a journaler simply opens the application and adds an entry with an “I Am Eating” button. Mobile journal entries can include a picture of the food, a description, and a rating of current mood (as seen in Figure 4). The myDECAF.org website allows providing additional detailed information about an entry, such as which meal of the day, the meal enjoyment rating, meal location, how many and with whom it was eaten, feelings after eating, and a description of the meal components (as seen in Figure 1). DECAF explicitly and intentionally does not log calories or other nutritional details, as our focus is on participant response to photo-based capture and reflection in comparison to prior journaling techniques.

Procedure

Participants installed DECAF on their own phone. We encouraged them to use the application for in-the-moment journaling and to then visit the website nightly to provide additional details. Participants were compensated \$20 for

every week they journaled their food and provided details on the website. The study consisted of a one-hour pre-study session, use of the journal for four weeks, and a one-hour post-study session. Some participants who kept thorough journals were given the option to continue for up to 4 more weeks, with an additional one-hour interview.

In the initial session, we interviewed participants about their health goals, past journaling experiences, and eating routines. In the post-study session, we asked multiple choice and Likert scale questions and then a semi-structured interview. The interview began by asking participants to reflect on their four weeks of DECAF usage. We finished with a series of questions about advantages, disadvantages, difficulties, and valuable aspects of any prior journaling methods as well as those for photo-based journaling with DECAF. We transcribed the semi-structured interviews and used open coding techniques to extract themes.

Participants

We recruited 27 participants to use DECAF for between 4 and 8 weeks (not including 3 drop outs). Participants ranged in age from 21 to 64 years (M: 39, SD: 13) and had a range of health goals and journaling experience. Although all field participants indicated a general goal of wanting to make healthier food choices, their specific goals ranged from substantial weight loss to transitioning their diet to be vegan or vegetarian. Participants were in two trials:

Trial 1 consisted of 14 participants (after 2 drop outs) from the Seattle area. Participants were recruited from university and local mailing lists based on interest in food journaling. This trial included several people on vegetarian, vegan, and low-processed food diets. 10 people had previous food journaling experience. This trial ran November to January.

Trial 2 consisted of 13 participants (after 1 drop out) recruited from the University of Rochester Medical Center using ResearchMatch. All had a BMI ≥ 25 , indicating they were overweight or obese. As in Trial 1, we recruited based on interest in food journaling, and 10 had previous experience. This trial ran January to February.

FIELD STUDY RESULTS

We present our field deployment results in terms of usage, the impact of lightweight journaling on challenges, the value of photos, and differences by journaler food goal.

Usage

Common challenges with long-term food journaling include compliance and data hoarding. Estimating compliance is difficult as there is no ground truth as to what food was consumed. To approximate compliance, we examine the journaling rate. Participants journaled for an average of 5.2 weeks, a total of 3569 entries, an average of 3.5 entries per participant per day. This suggests overall high usage.

We expected in-the-moment photo-based journaling to minimize hoarding, as a photo can only be taken before or during food consumption. To detect hoarding, we logged the eating time and the journaling time, then compared the

timestamps. We defaulted the eating time to “Now” and asked participants to change it to match when they ate. Participants generally journaled within 10 minutes of eating (86% of all entries). Because 94% of entries created within 10 minutes of eating contained photos of the food, they were not susceptible to hoarding. In contrast, a journal entry created more than 30 minutes after eating normally did not contain a photo (12% of all entries were created more than 30 minutes after eating, only 20% of which include a photo). When delayed entries did contain a photo, it was often of dirty plates or empty wrappers. Although such photos would be difficult or impossible for transcription by an automated system or by other people, participants reported they supported their ability to remember what they ate.

Impact of Lightweight Journaling on Challenges

Similar to our survey findings, all field participants with prior food journaling experience reported their prior techniques made packaged food and fast food easiest to log, with home-cooked meals being more challenging. In contrast, photo journals lowered this barrier and leveled the playing field among meal types. Taking a picture is equally difficult regardless of preparation, and participants rated all food types at the same difficulty. 60% of field participants with prior journaling experience reported they sometimes did not journal a meal with their prior technique because it was too difficult. With photo-based journaling in DECAF, only 22% reported not journaling because it was too difficult. Participants still reported difficulty when food is eaten over time (e.g., appetizer, main dish, dessert) or in a sampling manner (e.g., a buffet, at a party). These types of meals require several entries throughout dining, increasing burden and the likelihood of forgetting or choosing to not journal [11].

With many journaling methods, it is difficult to log a meal if a journaler does not know the exact ingredients. 65% of field participants with prior experience reported not journaling with their prior technique because they did not know the ingredients. Knowing meal composition does not impact the ability to journal a meal with photos, and none of our participants reported not journaling for this reason.

There are also often social challenges surrounding food journaling. 55% of field study participants with prior journaling experience reported this was a challenge with their prior technique. Although publicly taking photos of food with phones has become more accepted, participants reported similar challenges with photo journals. 52% reported feeling awkward photographing food in front of others. The types of meals reported as most socially awkward to photograph were restaurant meals, dinner at a friend’s house, and food at a party. We note these are also contexts in which food often comes over time, and so this challenge may interact with the above challenge.

Finally, although participants reported photo-based capture reduced barriers to journaling, simply forgetting to journal remains a challenge. 95% of participants with prior experience reported forgetting to journal with their prior

technique, and 93% of participants reported sometimes forgetting with DECAF. Because there is no ground truth in either case, we cannot determine if reducing barriers with photo-based capture impacts the frequency of forgetting. But this clearly remains a challenge for food journal design.

Value of Photos

Photos provide rapid capture, but people also need to obtain value from the data they capture. DECAF explicitly and intentionally does not log calories or other nutritional details, as we explore the value people obtain directly from the photos themselves. Of the 3569 entries journaled in the deployment, 3136 (88%) included photos. Many said photos were the most salient feature: *“the strength was obviously the photos”* (FP34), *“I think the pictures were great. With pictures you, even if there are no words there, you understand a lot”* (FP11). During the final interview, we asked participants to talk aloud as they reflected on the most recent weeks of their journal. Many described looking only at photos, ignoring other information they collected: *“I’m totally just looking at the picture”* (FP4), *“I’m just looking at the picture, that’s the interesting thing”* (FP11).

Who, What, Where, How

Photos were not merely *“the interesting thing”*, as interview participants reported that photo context supported much richer recall (e.g., where a meal was eaten, what other tasks had been accomplished that day, who was eaten with, and the preparation and makeup of the food). FP9 stated *“I can know what I ate, what I typically eat, I can remember the events, I can understand myself better”*. Photo background often contained enough detail that participants knew where they had eaten (as in Figure 5c): *“[mom] actually has nice tablecloths and really nice plates, so I know it’s her house”* (FP11), *“you can see my counter”* (FP3). Participants also reported purposely including context so they could later know where they had eaten (e.g., FP4 included her laptop when eating at work).

Some participants expressed an emotional connection to photos that captured happy times they had with friends and family: *“Having the picture reminded me of how I was feeling that day, and the context around it”* (FP10). Some also reported purposely including people in photos so that they could better remember those times (as in Figure 5a). FP11 said *“I purposely got my boyfriend’s hand [in the photo], because I wanted to remember that he was there”*.

Survey respondents had expressed concern that nutritional labels often do not provide the preparation of food, such as what oils were used or the level of processing. Conversely, some had expressed concerns that photos might hide condiments or other high-calorie portions of a meal. In our field study, we found participants could use their photos in seeing or remembering these details of food they had eaten. FP13 was on a low-processed diet, and described being able to tell if her food met her goal by quickly scanning photos for wrappers: *“From my pictures it’s pretty obvious to me if it was prepackaged or not.”* Similarly, some participants

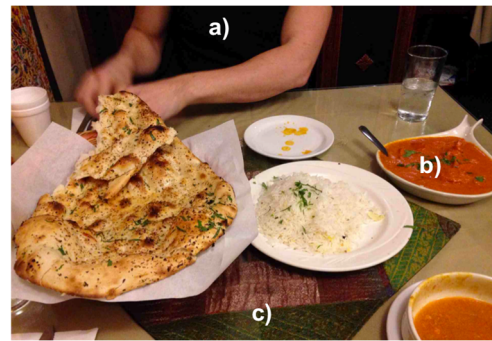


Figure 5. Participant photos supported rich recall, including a) with whom food was eaten, b) details of food that was eaten, c) context of where food was eaten.

reported scanning photos for color as an indication of the presence of more vegetables. Several said photos helped with determining portion sizes: *“It gave you an idea of what your portions are [...] ‘Wow, I ate way too much pasta in that bowl.’”* (FP24). Finally, participants reported using cues in the photos to remember food that was not actually in the photo: *“an empty muesli bowl looks different than an empty salad bowl, because my salad dressing always has balsamic vinegar in it, so it’s kinda brown, whereas muesli is kinda white”* (FP5). Overall, participants reported they could flexibly interpret photos during reflection, including remembering context that would be difficult or impossible to recover with an automated system or by another person.

Triggers and Trends

Participants were able to use photos in making deeper connections that attributed cause to context. They often identified the places they were at and the people they were with as influences in why they made certain food choices: *“[the photos] reminded me of what I ate and what was the situation”* (FP6), *“I know I ate all of these cookies because my friend came to visit”* (FP11). Participants were also able to use photos in picking out higher-level trends confirming beliefs they had about themselves: *“I eat too much pizza”* (FP10), *“I have salad for lunch every single day”* (FP5), *“For breakfast, I eat lots of the same things”* (FP4). They also identified previously unrecognized patterns: *“I don’t branch out as much as I thought I did, even when I go somewhere new, I kind of get what I always get somewhere else”* (FP10), *“I eat a lot of the same thing, and I eat kind of boring”* (FP19), *“I’m surprised at how many times I’m seeing things that I consider an exception to my diet!”* (FP4), *“I didn’t eat as many fruits and vegetables as I thought”* (FP16). Identifying triggers and trends can be an important use of a food journal in improving eating habits and identifying new goals. Participants used photos for this, but more explicit support could add lightweight tagging in support of more active sorting and filtering mechanisms, without imposing calories or nutritional details.

Awareness and Mindfulness

Wilde and Garvin define increased awareness of behavior as one of two complementary components in self-tracking [36]. Photo-based capture encouraged participants to journal at

the moment of eating, which they found helped them think about their food choices: *"The simple action of logging makes me think about what I eat and how much of it"* (FP6). Participants reported taking photos created additional mindfulness because they did not want unhealthy food to appear in their journal: *"The fact that there would be a picture made me have healthier snacks"* (FP19), *"Do I really want to eat this? I'm capturing this image"* (FP17), *"I didn't want to take a picture of chips, or a bunch of really bad food, so I guess that kinda helped me make more healthy food choices, just the act of taking a picture"* (FP2), *"when I had to take a picture of it, I was more worried about what was in the picture, that there should be some fruits and vegetables"* (FP16). Such reactions suggest calorie budgets or detailed nutritional information are not necessarily required for healthier in-the-moment decisions. If people already know what is healthy, the mindfulness of journaling can itself encourage healthier choices.

Differences by Goal

Our field study included two separate trials with participants with varying goals. Trial 1 contained participants with a general interest in food journaling, while Trial 2 contained only participants that were overweight or obese and trying to lose weight. Because our system did not contain calories or other nutrition details, we expected different reactions from participants according to their health goals. Although most participants across both trials saw value in photos as part of a food journal, we found differences in how the photos were used and the benefits they provided. Trial 1 participants generally found the lack of calories to be a strength, while most Trial 2 participants felt they needed calorie information to reach their weight goal: *"I need to know calories"* (FP24), *"calories and nutrients, the things in the food really matter to me the most"* (FP19), *"I think someone starting out really needs [calories]"* (FP20).

After using photo-based journaling, some Trial 2 participants changed their view, seeing additional value: *"I think you can tell a lot from the pictures. You might not have your calorie count. But, am I eating something too fattening? Is my portion too large?"* (FP28). When reflecting on their diary at the end of the study, several had strong reactions to actually seeing the photos of what they were eating: *"When I would get on the computer, I would look at the diary and realize that I was on a really bad road. I realized what I was eating for the last month. It was awful!"* (FP24) and *"The history was kind of a wake up call for me"* (FP25).

Several Trial 2 participants liked photos in conjunction with calorie information: *"I would LOVE if I could see the picture on MyFitnessPal"* (FP26). Many also decided to additionally track calories using other methods, using photos as a quick way to capture the foods consumed for later lookup: *"easier to figure out what the calories are from the pictures"* (FP22) and *"For some meals, it's just really easy to take a picture.... Rather than sit there and type in every ingredient"* (FP20). We have noted prior work

uses photos as an intermediate capture to support later calorie entry, and our results support such a usage. But our broader results also show this should not be required nor assumed as the primary usage, and journals should instead support a variety of goals enabled by photo-based capture.

DISCUSSION

We found that photo-based capture and reflection can directly support a variety of food journaling practices in support of diverse goals. We now discuss our results relative to challenges participants reported with their prior techniques.

Journaling Without Judgment

13% of survey participants and 45% of field participants reported that in their prior journaling they sometimes chose not to journal because food exceeded their calorie budget or because the food was unhealthy. In contrast, none of our field participants reported avoiding journaling an entry for this reason. Photo-based journaling supported capture while avoiding creating feelings of failure and judgment: *"[DECAF was] easier because there were no calorie counts, no judgments, but still makes you aware"* (FP14). Such reactions suggest a potential for some separation between in-the-moment capture and more goal-oriented reflection. We have noted the act of journaling itself creates mindfulness, but that "bad" moments can create a sense of judgment that undermines capture and therefore later reflection. This is especially damaging if failing to capture those "bad" moments prevents a journaler from correctly diagnosing a trigger, identifying a trend, or achieving a goal. A design opportunity exists for considering how to support capture of "bad" moments while promoting outside-of-the-moment reflection in the context of goals.

Role of Personalization

Field participants wanted to track aspects of their diet that were not supported by DECAF or other existing journals. These include whether a food was organic or grass-fed, the level of processing of a food, and the oils used when cooking. 37% of our survey participants with prior journaling experience reported they stopped journaling due to reduced value over time, so providing mechanisms to set and track varied personal goals could help journalers stay motivated. People change their goals over time, and there is an opportunity for systems that allow people to change the goals of their journaling. For example, many participants mentioned trying to lose weight and then keep it off while eating more nutritiously. These are two distinct goals, and the support a system should provide when a person is trying to lose weight may be different than when trying to maintain weight and eat nutritiously. Journals should be configurable to support evolving personal goals.

Active Reminders

The top reported reason for not journaling food in our survey was simply forgetting. Although using photos as a capture mechanism lowered the journaling barrier, our field participants also struggled with remembering to log. Future systems could combine lightweight capture methods with

automatic reminders to log. For example, research is examining detection of visual or audio characteristics that correspond to eating [1,3,29,32]. Another possibility would be using journal history to identify routines that can prompt reminders at likely eating times. In contrast to proposals for automated journaling, a combination of lightweight capture and active reminders could keep journalers involved in capture, thus providing the benefits of mindfulness while reducing the burden of remembering to journal.

Journaling During Transitions

Long-term compliance is often a goal in self-tracking, but our results suggest targeted journaling at critical times may provide benefits without requiring long-term adoption. We administered the study over a time containing food-related holidays (American Thanksgiving, Hanukkah, Christmas) as well as New Years Day (when many set health goals). For our student participants, the study also spanned the university transitions of finals week, winter break, and a new quarter. A trend in our interviews was a persistent optimism that, although their eating was not currently ideal, in the future it would be easier: *“I want to go back to the normal. The past month is a lot different and a lot of times I couldn't really have the food I wanted to eat.”* (FP9). Although optimism can be good, it can also encourage people to postpone changing behaviors because they hope it will be easier if they just wait a bit longer. Targeting journaling during times of transition may help people navigate these times with a higher level of awareness and help them implement habits in their new environment that can persist after journaling has ended.

Robustness to Missing Data

Survey respondents and field study participants reported many reasons for not logging a meal with prior techniques (e.g., forgetting, it being too difficult, not knowing the ingredients). Missed entries are particularly problematic for calorie-based food journals, as the primary feedback is quantitative (e.g., a sum relative to a budget, an average over the past week). Missed entries make this inaccurate, so one missed entry can derail an entire day or more of journaling: *“it showed the amount of calories you took in that week but if you didn't fill out most of the week it was sort of useless. So then I started with a lot of effort but as it started to go down, it sort of snow balled from there”* (FP2). As reported by Cordeiro et al. [11], participants reported that with prior techniques they often would not bother journaling after missing a single meal in a day, sometimes leading them to abandon journaling: *“Too hard to remember to do it after every meal. Then I got discouraged once I got behind and was never able to catch up again.”* (SP81).

In contrast, participants reported that forgetting to photograph a meal did not devalue journaling other meals, as each represented a self-contained data point. By focusing on a data presentation that does not require long periods of perfect compliance, missing a meal did not initiate longer periods of non-journaling. This suggests robustness toward

missing data should be considered in the design of food journals. Even if photos are not a primary format, alternative presentations could better preserve value and motivation for journaling in the face of missing data.

Interpretability of Data Representation

Prior work finds calorie journals are inaccurate by as much as 20% to 50% [19,20], and 46% of our survey respondents preferred food represented as photos over nutrition labels. Even respondents with prior food journaling experience expressed difficulty interpreting nutrition labels without the context of the foods. Although that context is available during capture of the food a person eats, many journals remove the context in daily or weekly summaries that focus on a summary of calories or other nutritional details. The result is often a journal that is both inaccurate and difficult to interpret in the context of a person's goals.

In contrast to measurement, photos emphasizes capture. Field study participants reported diverse value in photos as their primary data representation. Although some with specific weight-related goals also wanted calories, most felt photos provided information about what was eaten, how the food was cooked, with whom food was eaten, and the context surrounding the meal. Participants were able to interpret their journals to quickly determine whether they thought it was a healthy or unhealthy week, a personal judgment that can be difficult with nutritional summaries. Participants were also able to identify trends and triggers that would have been masked in a nutritional summary. Photo-based representation is thus familiar and interpretable, allowing journalers to leverage existing food knowledge. Although there are important questions about how to help people improve food knowledge, our results show an opportunity for designs to exploit existing knowledge in support of diverse food-related goals.

CONCLUSION

People bring a variety of goals to food journaling, and they report prior techniques fail to support or even undermine their self-tracking. Our work has examined direct use of photos in a food journal to support capture and reflection. We deployed a lightweight photo-based food journal with 27 participants for between 4 to 8 weeks. Participants report photos ease capture, present information that is important to them (e.g. food variety, level of processing, vegetables), and support reflection to identify triggers and trends. Our work thus provides support for photo-based journaling to augment or sometimes replace methods focused on calories or other nutritional details. Photos can support journaling relevant to a variety of food-related goals, while also removing or reducing barriers associated with common methods.

ACKNOWLEDGEMENTS

We thank Daniel Epstein, Julie Kientz, and Sean Munson for their feedback. This work was funded in part by the Intel Science and Technology Center for Pervasive Computing and by the National Science Foundation under awards OAI-1028195 and SCH-1344613.

REFERENCES

- Amft, O., Stäger, M., Lukowicz, P., and Tröster, G. Analysis of Chewing Sounds for Dietary Monitoring. *UbiComp 2005*, 56-72.
- Andrew, A.H., Borriello, G., and Fogarty, J. Simplifying Mobile Phone Food Diaries: Design and Evaluation of a Food Index-Based Nutrition Diary. *PervasiveHealth 2013*, 260-263.
- Arab, L., Estrin, D., Kim, D.H., Burke, J., and Goldman, J. (2011). Feasibility Testing of an Automated Image-Capture Method to Aid Dietary Recall. *Eur J Clin Nutr*, 65(10), 1156-1162.
- Barrett-Connor, E. (1991). Nutrition Epidemiology: How Do We Know What They Ate? *Am J Clin Nutr*, 54(1 Suppl), 182S-187S.
- 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. *CSCW 2012*, 475-484.
- Bird, G. and Elwood, P.C. (1983). The Dietary Intakes of Subjects Estimated from Photographs Compared with a Weighed Record. *Hum Nutr Appl Nutr*, 37(6), 470-473.
- Burke, B.S. (1947). The Dietary History as a Tool in Research. *J Am Diet Assoc*, 23(12), 1041-1046.
- Burke, L.E., Wang, J., and Sevvick, M.A. (2011). Self-Monitoring in Weight Loss: A Systematic Review of the Literature. *J Am Diet Assoc*, 111(1), 92-102.
- Chahoud, G., Aude, Y.W., and Mehta, J.L. (2004). Dietary Recommendations in the Prevention and Treatment of Coronary Heart Disease: Do We Have the Ideal Diet Yet? *Am J Cardiol*, 94(10), 1260-1267.
- Choe, E.K., Lee, N.B., Lee, B., Pratt, W., and Kientz, J.A. Understanding Quantified-Selfers' Practices in Collecting and Exploring Personal Data. *CHI 2014*, 1143-1152.
- Cordeiro, F., Epstein, D., Thomaz, E., Bales, E., Jagannathan, A.K., Abowd, G., and Fogarty, J. Barriers and Negative Nudges: Exploring Challenges in Food Journaling. *CHI 2015*, To Appear.
- Craig, M.R., Kristal, A.R., Cheney, C.L., and Shattuck, A.L. (2000). The Prevalence and Impact of 'Atypical' Days in 4-Day Food Records. *J Am Diet Assoc*, 100(4), 421-427.
- Frost, J. and Smith, B.K. Visualizing Health: Imagery in Diabetes Education. *DUX 2003*, 1-14.
- Grimes, A. and Harper, R. Celebratory Technology: New Directions for Food Research in HCI. *CHI 2008*, 467-476.
- Heizer, W.D., Southern, S., and McGovern, S. (2009). The Role of Diet in Symptoms of Irritable Bowel Syndrome in Adults: A Narrative Review. *J Am Diet Assoc*, 109(7), 1204-1214.
- Hollis, J.F., Gullion, C.M., Stevens, V.J., Brantley, P.J., Appel, L.J., Ard, J.D., Champagne, C.M., Dalcin, A., Erlinger, T.P., Funk, K., Laferriere, D., Lin, P.-H., Loria, C.M., Samuel-Hodge, C., Vollmer, W.M., and Svetkey, L.P. (2008). Weight Loss During the Intensive Intervention Phase of the Weight-Loss Maintenance Trial. *Am J Prev Med*, 35(2), 118-126.
- Kanfer, F.H. (1970). Self-Monitoring: Methodological Limitations and Clinical Applications. *J Consult Clin Psych*, 35(2), 148-152.
- Kong, F. and Tan, J. DietCam: Regular Shape Food Recognition with a Camera Phone. *BSN 2011*, 127-132.
- Lansky, D. and Brownell, K.D. (1982). Estimates of Food Quantity and Calories: Errors in Self-Report among Obese Patients. *Am J Clin Nutr*, 35(4), 727-732.
- Livingstone, M.B., Prentice, A.M., Strain, J.J., Coward, W.A., Black, A.E., Barker, M.E., McKenna, P.G., and Whitehead, R.G. (1990). Accuracy of Weighed Dietary Records in Studies of Diet and Health. *BMJ*, 300(6726), 708-712.
- Mamykina, L., Mynatt, E., Davidson, P., and Greenblatt, D. MAHI: Investigation of Social Scaffolding for Reflective Thinking in Diabetes Management. *CHI 2008*, 477-486.
- Mamykina, L., Mynatt, E.D., and Kaufman, D.R. Investigating Health Management Practices of Individuals with Diabetes. *CHI 2006*, 927-936.
- Mankoff, J., Hsieh, G., Hung, H.C., Lee, S., and Nitao, E. Using Low-Cost Sensing to Support Nutritional Awareness. *UbiComp 2002*, 371-376.
- Marr, J.W. (1971). Individual Dietary Surveys: Purposes and Methods. *World Rev Nutr Diet*, 13, 105-164.
- Mattila, E., Pärkkä, J., Hermersdorf, M., Kaasinen, J., Vainio, J., Samposalo, K., Merilahti, J., Kolari, J., Kulju, M., Lappalainen, R., and Korhonen, I. (2008). Mobile Diary for Wellness Management - Results on Usage and Usability in Two User Studies. *IEEE Trans Inf Technol Biomed*, 12(4), 501-512.
- Nelson, M., Atkinson, M., and Darbyshire, S. (1996). Food Photography II: Use of Food Photographs for Estimating Portion Size and the Nutrient Content of Meals. *Br J Nutr*, 76(1), 31-49.
- Noronha, J., Hysen, E., Zhang, H., and Gajos, K.Z. Platamate: Crowdsourcing Nutritional Analysis from Food Photographs. *UIST 2011*, 1-12.
- Purpura, S., Schwanda, V., Williams, K., Stubler, W., and Sengers, P. Fit4Life: The Design of a Persuasive Technology Promoting Healthy Behavior and Ideal. *CHI 2011*, 423-432.
- Rahman, T., Adams, A.T., Zhang, M., Cherry, E., Zhou, B., Peng, H., and Choudhury, T. BodyBeat: A Mobile System for Sensing Non-Speech Body Sounds. *MobiSys 2014*, 2-13.
- Sicherer, S.H. and Sampson, H.A. (2010). Food Allergy. *J Allergy Clin Immunol*, 125(2 Suppl 2), S116-S125.
- Stone, A.A., Shiffman, S., Schwartz, J.E., Broderick, J.E., and Hufford, M.R. (2003). Patient Compliance with Paper and Electronic Diaries. *Control Clin Trials*, 24(2), 182-199.
- Thomaz, E., Parnami, A., Essa, I., and Abowd, G.D. Feasibility of Identifying Eating Moments from First-Person Images Leveraging Human Computation. *SenseCam 2013*, 26-33.
- Tsai, C.C., Lee, G., Raab, F., Norman, G.J., Sohn, T., Griswold, W.G., and Patrick, K. (2007). Usability and Feasibility of PmEB: A Mobile Phone Application for Monitoring Real Time Caloric Balance. *Mobile Netw Appl*, 12(2-3), 173-184.
- Urist, J. My Fitness Band Is Making Me Fat: Users Complain of Weight Gain with Trackers. *Today.com*, July 16, 2014.
- Wansink, B. and van Ittersum, K. (2007). Portion Size Me: Downsizing Our Consumption Norms. *J Am Diet Assoc*, 107(7), 1103-1106.
- Wilde, M.H. and Garvin, S. (2007). A Concept Analysis of Self-Monitoring. *J Adv Nurs*, 57(3), 339-350.
- Zepeda, L. and Deal, D. (2008). Think Before You Eat: Photographic Food Diaries as Intervention Tools to Change Dietary Decision Making and Attitudes. *Int J Consum Stud*, 32(6), 692-698.
- Zhu, F., Bosch, M., Boushey, C.J., and Delp, E.J. (2010). An Image Analysis System for Dietary Assessment and Evaluation. *ICIP 2010*, 1853-1856.