Notifications in Food Logging Apps: A Review of Design Guidelines

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ABSTRACT

This paper presents a first exploration towards generating an overview of the design recommendations which have been issued on the topic of manual food tracking applications over the past 10 years. This is not only interesting for the field of food logging, but also as an exploration of how a systematic review of design recommendations could be done. By developing ways to retrieve, analyze, and evaluate published design recommendations from a meta-perspective, we are able to synthesize the design knowledge generated across disciplines, ultimately producing better design and research output. Design recommendations on the topic of mobile-based food tracking apps were retrieved from a literature review and then analyzed using qualitative coding. By zooming in on design recommendations related to notifications in mobile food tracking apps, this paper reveals the agreement and dissonance that exists both within design recommendations and against wider literature.

KEYWORDS

Design Recommendations • Food Logging Apps

1 Introduction

In Human Computer Interaction (HCI) literature and beyond, design recommendations are increasingly being offered as a contribution to the field. Design researchers and practitioners rely on these research-driven design recommendations as foundations for their work, investing time, effort and resources into their implementation, and potentially affecting millions of users. However, design recommendations can be conflicting due to the underlying nature of their research. In other fields, review formats such as the scoping review or the systematic review have been developed to account for the ambiguity of applying results from multiple researches. Yet these existing methods are driven by the review of scientific work, inherently lacking consideration for design perspective and methodology despite design increasingly shaping the world that we live in. To maximize the value of design recommendations for design researchers and practitioners, we must establish ways for gathering and synthesizing, as well as evaluating them. This paper presents a first exploration into generating a meta-perspective of design recommendations.

Sas et al. (2013) describe design recommendations as a form of design knowledge informed by 3 distinct sources -- practice informed (Fallman, 2003; Gaver & Martin, 2000; Zimmerman et al., 2010), fieldwork informed (Carroll, 1995; Hughes et al., 1997) and human science informed (Carroll & Long, 1991; Dix et al., 2003) design knowledge, of which all three appear in the design recommendations retrieved in this paper. They

describe the critical challenge in design of translating empirical findings into actionable ideas and note the surprising lack of empirical studies investigating implications for design. They also highlight the need to consider evaluation criteria for design implications in the future. Building on their insights, I take a pragmatic approach towards retrieving and synthesizing design recommendations from published literature and add to the conversation on the importance of evaluation. By developing ways to analyse published design recommendations from a meta-perspective, we are able to synthesize the design knowledge generated across disciplines, ultimately producing better design and research output.

Mobile-based food tracking applications have been taken as a focus area for this exploration as the space offers a wide and varied body of literature across disciplines, as well as being a rapidly evolving and increasingly popular topic. Within this domain, design recommendations relating to mobile notifications are focused on in detail as they are a particularly relevant topic for the HCI community, being widely used and applicable across applications. The agreement and dissonance found both within the design recommendations retrieved by this review, as well as against widely accepted research into notifications is highlighted.

Mobile-based food tracking is a multidisciplinary research area, as insight into an individual's food intake behaviour has many uses. Not only does food logging provide valuable insight for healthcare professionals to aid in diagnosis and treatment (Grimshaw et al., 2014; Karkar et al., 2017) and function as a data collection tool for researchers (Burke et al., 2011; Six et al., 2010), but it has also been adopted by many users for personal use, as well as the commercial weight loss and wellness industries (Lose it!, n.d.; My Fitness Pal, n.d.; My Food Diary, n.d.). As such, finding an accurate and reliable way to track the type and quantity of food someone consumes each day has been a long sought after goal in many fields. Advances in mobile technology have made mobile applications for personal food logging a logical and popular choice, and have contributed to the growing body of academic literature from the fields of HCI, Health, and Nutrition Research.

This paper contributes to the HCI literature by offering insight into publishing recommendations for designing mobile food tracking apps, as well as demonstrating how an overview of design recommendations could be generated and evaluated.

2 Related Work

2.1 Food Tracking

Historically, food records have been considered to be the "gold standard" in dietary assessment (Jain et al., 1996). When first introduced in the form of paper-based diaries, food recording provided a more convenient way for individuals to track their diet on a daily basis (Burke et al., 2008). Formal recording tools overcame the issues of short-term memory in dietary self-report (Doumit et al., 2016) which is experienced with food frequency questionnaires (Zepeda & Deal, 2008), and leads to unreliable records.

Research suggests manually recording detailed food intake raises awareness of consumption behaviours (Burke et al., 2011) and promotes individuals to adopt healthier eating practices(Nahum-Shani et al., 2018; Thomas & Bond, 2015). However, manually tracking food intake is also time consuming, tedious and burdensome (Cordeiro et al., 2015). This burden has led to underreporting of intake in various studies (Ahmad et al., 2016; Subar et al., 2003; Tooze et al., 2004) as well as significant underestimation of energy intake (Black et al., 1991; Martin et al., 1996).

In recent years, technology based interventions have been adopted with hopes of reducing the inaccuracy and user burden (Cordeiro et al., 2015; Thomaz et al., 2015). In particular, the proliferation of smartphones, and their pervasive nature in everyday life have made mobile application based food tracking a popular choice for nutrition researchers, healthcare professionals, designers and commercial app developers, with the mobile health market projected to grow to over $500 million by 2025 (Transparency Market Research, 2017). Mobile food tracking apps are considered a low-cost solution (Lee & Cho, 2017; Molina & Sundar, 2020) with the potential to support a variety of health goals (Azar et al., 2013; Chen et al., 2015; Davis et al., 2016; Fakih El Khoury et al., 2019, Plow & Golding, 2017). Prior research in HCI has focused heavily on reducing tracking burden (Cordeiro et al., 2015; Epstein et al., 2016; Noronha et al., 2011;) since it is considered to be a key component of making health apps successful (Lazar et al., 2015; Rooksby et al., 2014). This includes the introduction of extensive nutritional data bases (Cordeiro et al., 2015), food scanners (Andrew et al., 2013), natural language processing (Oh et al., 2018) and a variety of capture methods (Andrew et al., 2013). However there is mixed evidence in regards to mobile health apps, with some trials demonstrating efficacy (Ali et al., 2017; Turner-Mcgrievy, 2013) while others report poor results (Chen et al., 2019; Dodd et al., 2018). Studies also warn that mobile food tracking apps can lead to obsessive behaviour, the development of disordered eating habits (Eikey, 2016,2017; Eikey & Reddy, 2017; Tan et al., 2016) and can elicit feelings of judgement and shame (Cordeiro et al., 2015).

2.2 Notifications

Food Intake logging often encounters difficulties with incomplete food records (Chen et al., 2019; Lancaster et al., 2020) which research has attributed to users simply forgetting to log their food intake (Bentley & Tollmar, 2013;Cordeiro et al., 2015). Notifications reminding users to complete the task of food tracking are often implemented in an attempt to avoid this (Lose it!, n.d.; My Fitness Pal, n.d.; My Food Diary, n.d. Srinivas et al., 2019). Notifications have been defined as visual cues, auditory signals, or haptic alerts generated by an application or service that relays information to a user outside of the current focus of attention (Iqbal et al., 2011). On mobile phones, notifications inform the user about a variety of events, from receiving a message on social media to notifications about system updates. Applications in particular generate an increasingly large number of notifications to encourage users to engage (Pielot et al., 2014; Shirazi et al., 2014), with many users not even realizing how many notifications they receive (Weber et al., 2016). Notifications have been found to be disruptive (Kushlev et al., 2016; Leiva et al., 2012; Mohrotra et al., 2016), with their interruptive nature found to affect task completion time (Czerwinski et al.

2000; Horvitz, 2001; Monk et al., 2002) as well as impact the emotional state of the user (Pielot & Rello, 2015, 2017). As such, users must negotiate the trade off between disruption and awareness which notifications cause (Czerwinski et al. 2004; Hudson & Smith, 1996; Lin et al., 2013; ; Iqbal & Bailey, 2010; Iqbal & Horvitz, 2010a, 2010b). In order to make effective use of notifications, research suggests that they should contain relevant and high quality information (Ashley & Tuten, 2015; Attenberg et al., 2009), should arrive at opportune moments (Fischer et al., 2011; Okoshi et al., 2014, 2015a, 2015b) and the content should be actionable (Shirazi et al. 2014). Vibrational notifications have been found to elicit the fastest response time (Change & Tang, 2015; Mehrotra et al. 2016), while both auditory and vibrational alerts (as opposed to passive, visual notifications) are more likely to be forgotten when not immediately answered (Mashhadi et al., 2014) and repeat notifications have been found to be annoying which can lead to users ultimately deleting the app (Felt et al., 2012, Shirazi et al., 2014).

2.3 Meta-Reviews

Reviews of published literature from a meta-perspective are particularly valuable in bringing together separately conducted studies and synthesising their results (Green, 2005). They are characterized by a methodical and replicable methodology and presentation (Booth & Grant, 2009) and provide opportunity for identifying contradictions and dissonance within the literature. They also facilitate understanding of how individual studies fall together to comprise the larger research space (Baumeister & Leary, 1997; Prinstein & Patterson, 2013; Siddaway et al., 2019).

2.3.1 Design Recommendations

The value and nature of design recommendations and implications on a higher level has been the focus of several papers within the HCI community. Sas et al. (2013) synthesize different types of design implications into a framework to guide their generation. Through interviews with experts, they offer an overview of types of design implications such as requirements, sensitizing concepts (Blumer, 1954), design heuristics and design principles. They also consider evaluation criteria of implications for design, such as empirical validity -- *is the implication grounded and tested?*, theoretical validity -- *does the literature support the implication and vice versa?*, and actionability -- *can the implication be acted upon by technologists?.* The inclusion and generation of design recommendations is not without criticism, with Dourish (2006) offering criticism on the relationship between implications for design and ethnographic research, arguing that measuring ethnographic research against the implications it can provide for design is not the best way to capture and maximize the approaches value.

2.3.2 Meta-analysis

There exists a hierarchy within the methods of literature review ranging from a narrative review to a full systematic review with meta-analysis, increasing in confidence level. Where a narrative literature review summarises a body of literature by presenting comprehensive background research of a topic, a systematic literature review undertakes a more rigorous approach to answer specific questions and promote research knowledge

(Ryan et al., 2007). Systematic review can also be accompanied by meta analysis - analysing findings using a standardized statistical procedure (Coughlan et al., 2007) or meta synthesis -- evaluating and analysing findings from more qualitative studies (Danson & Arshad, 2014). Existing literature review methods and reporting guidelines have been developed primarily driven by scientific research such as medicine, with meta-analysis often being applied to determine effect sizes of interventions.

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) is considered as the standard for reporting systematic reviews and meta-analyses (Moher et al., 2009). PRISMA consists of a 27 item checklist and a 4 phase flow diagram which were developed primarily to improve the quality and transparency of systematic reviews and meta-analyses in healthcare. It can be used both by researchers as a checklist of what to include when reporting on systematic reviews and meta-analyses, and by reviewers to critically appraise published systematic reviews. A well conducted systematic review process should be easily understandable and replicable by other researchers. PRISMA details items to include to support that, such as establishing and reporting on eligibility criteria and how information sources were critically assessed for risk of bias, detailing study selection and methods used in the data collection process, and reporting on the synthesis of results (Moher et al., 2009). Some items such as an *explicit statement of questions being addressed with reference to Participants, Interventions, Comparisons, Outcomes and Study design* (PICOS) are not well suited to a review of design recommendations, nor are quantitative meta-analysis methods such as confidence intervals or measures of consistency.

In this paper, the PRISMA checklist has been considered and followed where applicable, however this review of design recommendations does not fit perfectly into the structure outlined in PRISMA as it does not account for the nuances of design perspective and methodology. Without ways of synthesising design recommendations, we risk misleading designers who base future work on conflicting recommendations. As such, we must create new approaches which facilitate evaluation of design recommendations.

3 Method

3.1 Search Strategy

In order to investigate the output of design recommendations relating to food intake tracking using mobile applications in academic literature, relevant journal articles published between January 01, 2010 and May 01, 2020 were searched from the ACM Digital Library, Scopus and Web of Science. The year 2010 was selected because although the first Apple App store was established in 2007, reporting on mobile food tracking apps took off from 2010 and 10 years was a manageable time frame for this study.

As can be seen in table 1, key search terms were defined based on the central focus of *food tracking mobile applications,* with the same final search query being applied across databases and including:*((food) OR (nutri*) OR (calor*) OR (diet*) OR (eat*))* AND *((track*) OR (log) OR (logging) OR (logger) OR (logged) OR (record*) OR (diar*) OR*

(journal))* AND *(((mobile] OR (smartphone) OR (phone)) AND (("app") OR (application))).* The search was performed for the Title, Abstract and Keywords of a paper. Truncation was used to capture all variations of key terms (eg. track* also returns *track(s), tracker(s), tracked, tracking)* however was not used for "Log", as too many queries were returned which included *logic.* The search targeted published research in conference proceedings and scholarly journals, written in English. For a complete overview of the applied search strategy, please see Appendix A.

Table 1: Search Operators

Concept	***Food***	***Tracking***	***Mobile***	***Applications***
Key Words	**-food** **-nutrition** **-calorie** **-diet** **-eat**	**tracking** **logging** **diary** **record**	**mobile** **smartphone** **phone**	**app** **application**
Search	**food** **nutri*** (nutrition, nutritionist(s), nutrient(s), nutritional) **calor*** (calorie(s), caloric) **diet*** (diet(s), dietary, dieting, dietician(s)) **eat*** (eat	**track*** (track, tracks, tracker(s), tracking) **log** **logging** **logger** **logged** **Diar*** (diary, diaries) **Journal*** (journal(s), journaling) **record*** (record(s), recorded, recording(s))	**mobile** **smartphone** **phone**	**"app"** **application**

3.2 Selection Process

3.2.1 Inclusion

Titles and abstracts retrieved by the above search strategy (N= 2352) were imported using Zotero software and duplicates were removed (n=270). They were then screened against the following criteria: (1) the article focused on the design, use or assessment of a smartphone application for manual food intake logging; (2) the study reported on a period of user testing (field deployment, surveys, interviews); (3) the article was published in English and (4) the article was published between January 1, 2010, and May 1, 2020.

3.2.2 Exclusion

Studies were excluded if (1) the app used automatic data capture and did not require manual logging from the user. This was to keep the scope of the review manageable and the content comparable. For example, automatic tracking from body worn sensors or photo recognition systems were excluded. (2) the app only tracked one specific food intake measure (e.g., salt). This was to maintain the ability to compare applications. Tracking only one type of food would significantly reduce burden and would not be comparable to tracking one's entire diet. (3) the app was designed specifically for diabetes management. With diabetes, daily food intake awareness is extremely intrinsically motivated as it is crucial to staying alive, and is thus not comparable to many other user contexts (4) the research was conducted with participants < 18 years as their target group. The context of children, especially young children, is not comparable with that of most adult focused research. Children often rely on a third party (parent or caregiver) to input their food intake and thus the burden of tracking is not comparable.

In the next step, articles for which inclusion was unclear from the abstract were retained for full text screening. Following review of titles and abstracts, full texts of the included papers were retrieved and again reviewed based on inclusion criteria, with the added criteria of: (6) the study included a design recommendation, guideline, or implication. For the purpose of this review, design recommendations have been considered as any statement in a paper which makes a suggestion about how future designs should be carried out. This includes the terminology “recommendations”, “guidelines”, “considerations” or “designers should…”. Finally, 10 papers were included. Figure 1 presents the *PRISMA* Flow Diagram of the study selection progress (Moher et al., 2009).

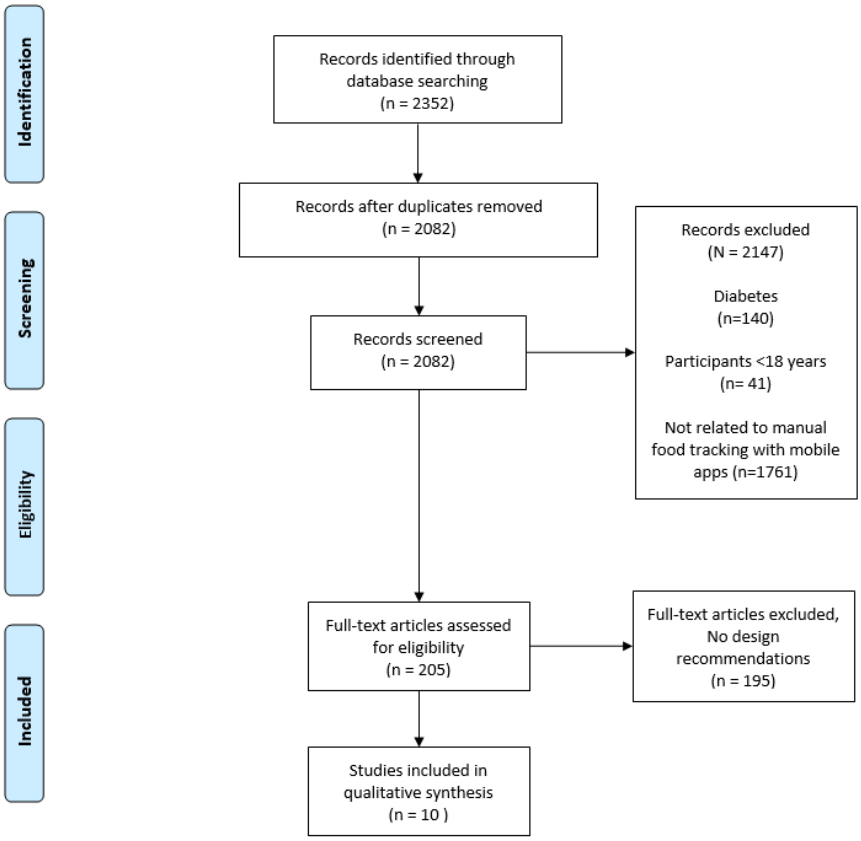

Figure 1: Prisma Flow Diagram

3.3 Data Extraction and Analysis

Each of the 10 remaining papers were read in full and data was extracted into a customized form which can be seen in appendix B, including:

- Article information: title, year, publication venue and type (conference/journal)
- Participant demographics
- The objective and context of the paper
- The app employed
- The testing period if relevant
- The data source (e.g., field deployment, interview, survey)

Design recommendations were extracted and entered verbatim from each paper into the design recommendations form, including the wording which signalled a recommendation was being made as can be seen in appendix C. After compiling the design recommendations, they were imported into MAXQDA 2020 (VERBI Software, 2019) and a hybrid process of inductive and deductive thematic analysis were used to develop the code system. Codes which were developed deductively included predefined codes such as *Motivation: Intrinsic* and *Motivation: Extrinsic,* whereas some codes, such as *Strategy: Reflection* and *Strategy: Health Literacy* were developed inductively during coding. To

allow for transparency and reproducibility, a code book (as can be seen in appendix E) has been developed and reported on, based on the structure outlined by MacQueen et al. (2008). It includes each code accompanied by a definition of when to apply it, and an example. After coding was completed, the frequency of code occurrences within papers (figure 2) and within individual design recommendations (figure 3) were analysed using frequency tables. Code relations were also analysed by generating co-occurrence tables of codes both within papers (figure 4) and within individual design recommendations (figure 5).The findings of this process are presented below.

	Frequency	Percentage
Reducing tracking burden	9	90,00
Notifications	8	80,00
Behaviour change	7	70,00
Social support	5	50,00
Extrinsic	5	50,00
Personalization	4	40,00
Health	4	40,00
Emotional well-being	3	30,00
Gamification	2	20,00
Reflection	2	20,00
Weight-loss	2	20,00
Intrinsic	2	20,00
Localization	1	10,00
eHealth Literacy	1	10,00
Privacy	1	10,00
DOCUMENTS with code(s)	10	100,00
DOCUMENTS without code(s)	0	0,00
ANALYZED DOCUMENTS	10	100,00

Figure 2: Frequency table of code occurrence per paper.

	Frequency	Percentage
Reducing tracking burden	37	29,60
Behaviour change	25	20,00
Notifications	13	10,40
Social support	10	8,00
Emotional well-being	9	7,20
Personalization	5	4,00
Weight-loss	5	4,00
Extrinsic	5	4,00
Reflection	4	3,20

Health	4	3,20
Intrinsic	3	2,40
Gamification	2	1,60
Localization	1	0,80
eHealth Literacy	1	0,80
Privacy	1	0,80
TOTAL	125	100,00

Figure 3: Frequency table of code occurrence per design recommendation.

4 Results

Overall, the literature search retrieved 2352 potential papers. After excluding irrelevant papers and articles which did not fit the inclusion criteria, 212 full text papers were retrieved and reviewed, of which 10 were finally included in this analysis (figure 1).

4.1 Descriptive analysis of selected studies

8 of the 10 papers included in the final subset were published between 2017 and 2020, with 2018 having the highest occurrence (n=4). 6 papers in the final subset reported based on the use of an existing app, 3 of which allowed participants to choose their own commercially available app (Honary et al., 2018; Lee & Cho, 2017; Tang, et al., 2014), and 3 requiring use of a specific commercially available app (Barbarin et al., 2018; Lin et al., 2018; Wei et al., 2020). The remaining 4 papers of the final subset reported on apps which were developed specifically for the study. Reported testing periods ranged from 3 to 90 days. Two papers in the final subset (Lin et al., 2018; Wei et al., 2020) used data sets from general use of an existing app with no specific testing period. Reported methods included combinations of participant and expert interviews (n=5), surveys (n=5), analysis of logging and usage data (n=4), workshops (n=2) and field deployments. The most frequently applied research methods within the final subset of papers were interviews (n=6) and surveys (n=5). 48% of all participants reported on were female.

4.2 Design Recommendations

The examination of the remaining 10 papers revealed 74 design recommendations, with a median of 7 recommendations per paper as detailed in Appendix C. The content of these recommendations were thenqualitatively coded. All papers in the final subset (n=10) included design recommendations to *reduce tracking burden* with 37 unique recommendations (29.6%). The majority of remaining papers also included recommendations focused on *notifications* (n=8) with 13 unique recommendations. Co-occurrence of codes within papers can be seen in figure 4, whereas co-occurrence of codes within unique recommendations can be seen in figure 5. Behaviour change and reducing tracking burden co-occurred the most frequently within recommendations (n=7), followed by behaviour change and weight-loss (n=5), notifications and reducing tracking burden (n=4), and emotional well-being and social support (n=4).For the purpose of this paper, design recommendations focusing on notifications are elaborated upon. Notifications were chosen as they are widely used, insights are relevant across application

domains and there is sufficient literature within HCI to compare and contrast findings. A full overview of the notifications relating to mobile food tracking can be found in appendix D.

	Codes		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Strategy\eHealth Literacy	1	-														
2	Strategy\Reflection	2	0														
3	Strategy\Localization	3	0	0													
4	Strategy\Gamification	4	0	1	0												
5	Strategy\Reducing tracking burden	5	1	2	1	1											
6	Strategy\Behavior change	6	1	2	1	2	6										
7	Technology\Privacy	7	0	0	0	0	1	1									
8	Technology\Personalization	8	0	1	0	0	4	2	1								
9	Technology\Notifications	9	0	2	1	2	7	5	0	3							
10	Physiological\Health	10	1	2	0	1	4	4	0	1	3						
11	Physiological\Weight-loss	11	0	1	0	0	2	2	1	2	1	1					
12	Psychological\Social support	12	1	2	1	1	5	5	0	1	4	4	1				
13	Psychological\Emotional well-being	13	0	2	1	1	3	3	0	1	3	2	1	3			
14	Motivation\Extrinsic	14	0	2	0	2	4	5	1	2	4	3	2	3	2		
15	Motivation\Intrinsic	15	0	2	0	1	2	2	0	1	2	2	1	2	2	2	-

Figure 4: Co-occurrence of codes in papers

Figure 5: Co-occurrence of codes in recommendations

	Codes		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Strategy\eHealth Literacy	1	-														
2	Strategy\Reflection	2	0	0													
3	Strategy\Localization	3	0	0	0												
4	Strategy\Gamification	4	0	0	0	0											
5	Strategy\Reducing tracking burden	5	1	2	1	0	0										
6	Strategy\Behavior change	6	1	3	0	1	7	0									
7	Technology\Privacy	7	0	0	0	0	0	0	0								
8	Technology\Personalization	8	0	0	0	0	3	1	0	0							
9	Technology\Notifications	9	0	1	0	0	4	1	0	2	0						
10	Physiological\Health	10	0	0	0	0	1	3	0	0	0	0					
11	Physiological\Weight-loss	11	0	0	0	0	2	5	0	1	0	1	0				
12	Psychological\Social support	12	0	1	0	0	2	1	0	0	1	0	0	0			
13	Psychological\Emotional well-being	13	0	0	0	0	0	2	0	0	0	0	0	4	0		
14	Motivation\Extrinsic	14	0	0	0	0	0	4	0	1	1	3	2	0	0	0	
15	Motivation\Intrinsic	15	0	0	0	0	0	3	0	0	0	0	0	0	0	0	-1

4.3 Notifications

Eight papers of the final subset revealed 13 unique recommendations relating to notifications as detailed in Appendix F. They offered recommendations for personalization of both content and timing of notifications, types and features of notifications to include and avoid, as well as reasoning for implementing notifications. In the following list, I give a brief overview of these recommendations and summarize the agreement or dissonance that exists between them.

4.3.1 Notifications: Personalization

2 papers recommend allowing users to personalize the timing and frequency of notifications. Barbarin et al. (2018) also recommend allowing personalization of subject matter, while Bentley & Tollmar (2013) suggest that this optimizes the long term effectiveness of notifications.

> *Although most current HIT designed for weight management does not allow for personalization of the types of encouraging messages users receive, they should allow feature tailoring (e.g., timing, frequency, subject matter, etc.).* (Barbarin et al., 2018.)

> *Based on our findings, in order for notifications to be the most effective over the long-term, they should be: User Configurable: time and frequency of notifications set by the user.* (Bentley & Tollmar, 2013)

Srinivas et al. (2019) recommend prioritizing certain app notifications over others to increase the user's attention.

> *From this extensive effort, we suggest that future work attempting to conduct momentary assessments should achieve the following minimum specifications to support increased user engagement: (3) increase participant's attention with a notification that is prioritized over other app notifications in the receiving device.* (Srinivas et al., 2019)

> *From this extensive effort, we suggest that future work attempting to conduct momentary assessments should achieve the following minimum specifications to support increased user engagement: (4) limit the time window within which a participant can respond to a question to capture situations accompanying a behaviour.* (Srinivas et al., 2019)

While the recommendations from Barbarin et al. (2018) and Bentley & Tollmar (2013) are in agreement that the timing and frequency of notifications should be set by the user themselves, there is some discord with the Srinivas et al. (2019) recommendations to prioritize certain notifications over others, and limit the time window for response, both without asking the user, which reduces the users' ability to customize their app experience.

4.3.2 Notifications: Delivery

2 papers make practical recommendations for the execution of notifications. Srinivas et al. (2019) recommend repeating auditory alerts to prompt user response:

> *From this extensive effort, we suggest that future work attempting to conduct momentary assessments should achieve the following minimum specifications to support increased user engagement: (5) repeat auditory alerts to remind participants to respond.* (Srinivas et al., 2019)

Bentley & Tollmar (2013) recommend that notifications should be non-interrupting by avoiding ringing or vibrating in order to be effective long term.

> *Based on our findings, in order for notifications to be the most effective over the long-term, they should be : Non-interrupting: not ringing or vibrating.* (Bentley & Tollmar, 2013)

While Honary et al. (2018) recommends that reminders should avoid being time based in order to prompt task completion all together, but rather the purpose of reminders should encourage self-reflection and habit formation.

> *Rather than focusing on temporal reminders to complete a daily task, apps should encourage a process of self-reflection and habit formation.*(Honary et al., 2018)

The recommendation from Srinivas et al. (2019) to repeat auditory alerts in order to prompt response from the user is in direct contrast to those of Bentley & Tollmar (2013) who recommend avoiding ringing alerts entirely, and Honary et al. (2018) who recommends completely avoiding task completion prompts.

4.3.3 Notification: Calls to Action

Lin et al. (2018) make recommendations based on the content of notifications, specifically content which targets user re-engagement. They recommend using extrinsically motivational phrases in notifications to peak users' curiosity and prompt them to return to self-tracking with goal driven content.

> *Here, one could consider interventions targeted at getting previous users with such intents to re-engage (e.g., notifications or emails such as "We saw you have not checked your resting heart rate in a while. It might have changed!")* (Lin et al., 2018)

> *Here, one can consider, for example, performance/goal-driven interventions such as "Can you still run a 10k in 53 minutes?" or "Can we help you manage your weight?"* (Lin et al., 2018)

Tang et al. (2014) also recommend that notifications can serve the purpose of re-ordering goal priorities.

> *Notifications and reminders can also be helpful and these may serve to reorder goal priorities.* (Tang et al., 2014)

There is a level of agreement between these recommendations as both Tang et al. (2014) and Lin et al. (2018) recommend using the notification as an opportunity to re-engage the user with their goals.

4.3.4 Notifications: Entering Information

Lancaster et al. (2019) recommend the implementation of notifications with the purpose of warning users of potential faults in their food logging data and prompting retroactive editing to increase accuracy.

> *Incorporation of warning notifications or error codes; to allow and encourage participants to self-check entries with missing or excessively large quantities, and for food items requiring more details.* (Lancaster et al., 2019)

While Srinivas et al. (2019) recommend limiting the time frame in which the user can respond to a notification.

> *From this extensive effort, we suggest that future work attempting to conduct momentary assessments should achieve the following minimum specifications to support increased user engagement: (4) limit the time window within which a participant can respond to a question to capture situations accompanying a behaviour. (*Srinivas et al., 2019)

These two recommendations are conflicting in that Lancaster et al. (2019) encourages allowing users to change and improve the quality of their logging data retroactively, Srinivas et al. (2019) recommend that limiting the length of time during which a user can enter their data increases accuracy by capturing situations close to real-time.

5 Discussion

In conducting this review, I sought to generate an overview of the design recommendations which have been issued on the topic of manual food tracking over the past 10 years. This is not only interesting for the field of food logging, but also as an exploration of how a systematic review of design recommendations could be done.

5.1 Dissonance within design recommendations

A closer look at the design recommendations relating to notifications in mobile based food tracking apps reveals not only dissonance amongst the extracted recommendations, but also against wider accepted literature and theory on notifications. For example, Srinivas et al. (2019) recommend repeated auditory alerts to improve engagement, while Bentley & Tollmar (2013) suggest that alerts should be non-interrupting (not ringing or vibrating) to be effective long term. To properly understand the discord between the two, we must first examine the context behind the recommendations to assess whether they are comparable. While Srinivas et al. (2019) report on developing an app to support ecological momentary assessment to be implemented in nutrition research, Bentley & Tollmar (2013) report on developing an app that supports individual users in developing personal insight into their eating behaviour. Although slightly different contexts of use, both studies implement notifications with the aim to improve and increase user engagement, with both taking *number of tracking occasions* as measurements of engagement. Srinivas et al. (2019) implemented repeated ringing alerts (3 alerts at 10 minute intervals to prompt logging of food) and reported a 20% higher tracking rate than without the implementation of ringing alerts. Bentley & Tollmar (2013) reported a 51% increase in tracking when

passive notifications (silent notifications appearing in the notification bar on participants' mobiles phones) were implemented than when no notifications were implemented. If we look to wider research in the field of notifications, we find disagreement between Srinivas et al. (2019) recommendation and the work of Shirazi et al. (2014) and Felt et al. (2012) who detail that repeat notifications are more likely to prompt users to delete the app which would ultimately decrease engagement [40,84]. We also find theoretical evidence in literature supporting the recommendation of Bentley & Tollmar (2013) in the work of Mashhadi et al. (2014) who found that a passive visual cue had the highest impact on users remembering to return to their unread notifications.

5.2 Difficulties

The above discussion on the dissonance that exists within design recommendations highlights the need to develop ways to analyze the output of design recommendations from a meta-perspective. Established methods of conducting systematic reviews and meta-analysis are driven by reviewing scientific work. The rigor that exists in scientific reporting lends itself well to generalizable quantitative analysis such as effect size, and study setups such as randomized control trials offer higher confidence in reported outcomes. However, considerations for the design perspective and methodology are not present in existing review methods, despite the fact that design is increasingly shaping the world that we live in.

To demonstrate the value of design recommendations as valid research output, they should be able to be implemented to make future work better. However, without evaluation criteria it is difficult to apply retrieved design recommendations with confidence. Establishing these evaluation criteria is both a challenge and an advantage of taking a meta-perspective on design recommendations. Sas et al. (2013) outlines evaluation criteria for individual design implications, such as empirical validity -- i*s the implication grounded and tested?*, theoretical validity -- *does the literature support the implication and vice versa?,* and actionability -- *can the implication be acted upon by technologists?*. Taking examples from the design recommendations relating to notifications retrieved by this paper, we can conduct a brief evaluation by these criteria.

5.2.1 Empirical Validity

The presence of user testing as an inclusion criteria in this review increases the empirical validity, however improved reporting of design decisions in the literature would allow reviewers to trace back and demonstrate that a design recommendation is grounded.

5.2.2 Actionability

The *actionability* of the design requirements is varied, with more prescriptive recommendations such as *Incorporation of warning notifications or error codes; to allow and encourage participants to self-check entries with missing or excessively large quantities, and for food items requiring more detail*s (Lancaster et al., 2019) providing concrete and highly actionable recommendations, whereas others would require further exploration in order to be implemented, for example with Honary et al.'s (2018)

recommendation of *rather than focusing on temporal reminders to complete a daily task, apps should encourage a process of self-reflection and habit formation.*

5.2.3 Theoretical Validity

To assess the theoretical validity, we compare and contrast the retrieved design recommendations against wider relevant literature. The added advantage of building an overview of design recommendations within a space is that they can also be assessed against each other as a measure of theoretical validity.

While these evaluation criteria are a good start to assessing individual design recommendations, more robust methods should be developed to evaluate design recommendations from a meta-perspective. In particular, the context from which a recommendation was generated is a highly relevant consideration as we attempt to compare and contrast studies. Limiting the review to one highly specified context would risk losing interesting and translatable design recommendations from related areas, however some contexts would simply not generate transferable recommendations. Future work should focus on building more robust evaluation criteria for taking a meta-perspective on design recommendations.

6 Limitations

The most significant limitation of this research is that the literature review was undertaken by only one researcher. To achieve a much higher confidence level that all possible design recommendations have been found and extracted, at least one other researcher (ideally more) would also screen the retrieved papers. In the event that a researcher was unsure whether to include or exclude, they could discuss with the second researcher and if no conclusion could be reached a third researcher would have been brought in to break the disagreement. However, the possibility of missed inclusion articles does not detract from the overall goal of attempting to develop an approach to generate an overview of design recommendations.

Another limitation of this research is that papers were only retrieved from the past 10 years (January 01, 2010 - May 01, 2020). Since the first Apple App Store was released in 2007, there is a possibility that papers published between 2007 and 2010 were missed, however there is an exponential increase across databases of mobile-based food tracking research from 2010.

A final limitation is that due to the scope and time frame of this research, deeper evaluation of included literature could not be conducted. For example, risk of bias and critical evaluation of the study design was not performed. This could mean that unreliable studies are included. An interested example is that one study (Srinivas et al., 2019) produced a lot of dissonance against other studies. This warrants taking a closer look at this study to evaluate its quality further.

7 Conclusion

In this paper, a first attempt at generating an overview of design recommendations for notifications in the context of mobile-based food logging. By conducting a systematic literature search of 3 data bases (Scopus, ACM Digital Library and Web of Science) to retrieve published design recommendations and then using qualitative coding to highlight the agreement and dissonance that exists between them, the advantages and difficulties of generating such an overview are explored. The results show that there exists dissonance between recommendations for notifications in the mobile food intake tracking space and demonstrate the value of taking a meta-perspective on design recommendations. This research highlights possibilities for future research and methodology development toward generating overviews of design recommendations

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APPENDICES

Appendix A: Search Strategy

Concept	*Food*	*Tracking*	*Mobile*	*Applications*
Key Words	**-food** **-nutrition** **-calorie** **-diet** **-eat**	**tracking** **logging** **diary** **record**	**mobile** **smartphone** **phone**	**app** **application**
Search	**food** **nutri*** (nutrition, nutritionist(s), nutrient(s), nutritional) **calor*** (calorie(s), caloric) **diet*** (diet(s), dietary, dieting, dietician(s)) **eat*** (eat	**track*** (track, tracks, tracker(s), tracking) **log** **logging** **logger** **logged** **Diar*** (diary,diaries) **Journal*** (journal(s), journalling) **record*** (record(s), recorded, recording(s))	**mobile** **smartphone** **phone**	**“app”** **application**

Data Base	limits	Full Search Query	Results
ACM Digital Library	Publication Date: (01/01/2010 TO 06/01/2020) Language: English	[[Abstract: food] OR [Abstract: nutri*] OR [Abstract: calor*] OR [Abstract: diet*] OR [Abstract: eat*]] AND [[Abstract: track*] OR [Abstract: log] OR [Abstract: logging] OR [Abstract: logger] OR [Abstract: logged] OR [Abstract: record*] OR [Abstract: diar*] OR [Abstract: journal*]] AND [[Abstract: mobile] OR [Abstract: smartphone] OR [Abstract: phone]] AND [[Abstract: "app"] OR [Abstract: application]] AND [Publication Date: (01/01/2010 TO 06/01/2020)]	**307**
Scopus	Publication Date: 2010-2020 Language: English	(TITLE-ABS-KEY (food O nutri* OR calor* OR diet* OR eat*) AND TITLE-ABS-KEY (Track* OR log OR logging OR logger OR logged OR record* OR diar* OR journal*) AND TITLE-ABS-KEY (mobile OR smartphone OR phone) AND TITLE-ABS-KEY ("app" OR application)) AND PUBYEAR > 2009 AND PUBYEAR < 2021 AND (LIMIT-TO (LANGUAGE , "English"))	**1520**
Web of Science	Publication Date: 2010-2020 Language: English	TOPIC: (food OR nutri* OR calor* OR diet* OR eat*) AND TOPIC: (track* OR log OR logging OR logger OR logged OR record* OR diar* OR journal*) AND TOPIC: ((mobile OR smartphone OR phone) AND ("app" OR application)),Timespan: 2010-2020	**525**

Appendix B: Data Extraction Form (overview of papers)

Year	Authors	Title	Venue	User Group	Objective	Food Tracking	Research Method
2018	Barbarin, A.M., Saslow, L.R., Ackerman, M.S., & Veinot, T.C.	Toward health information technology that supports overweight/obese women in addressing emotion- and stress-related eating	CHI	N=22, ≥18 years, % Female = 100%, BMI ≥ 25	How HIT can support overweight/obese women curb ESRE behavior.	Lose It! App, 10 days	Cross sectional, semi-structured interviews (N = 22)
2013	Bentley, F., Tollmar, K.	The power of mobile notifications to increase wellbeing logging behavior	CHI	N=60, 20-69 years,	We demonstrate the power of passive mobile notifications to increase logging of wellbeing data, particularly food intake, in a mobile health service.	Health Mashups app, 90 days	Surveys, Interviews, Statistical analysis of use
2018	Lin, Z., Althoff, T., Leskovec, J.	I'll Be Back: On the Multiple Lives of Users of a Mobile Activity Tracking Application	WWW	N=1 329 767, Median age= 32 years, %Female= 48.5%.	a large-scale observational study of user re-engagement patterns within a mobile activity tracking application.	Argus by Azumio App	Observational study
2018	Lukoff K., Li T., Zhuang Y., Lim B.Y.	TableChat: Mobile food journaling to facilitate family support for healthy eating	JMIR Mhealth Uhealth	N=189 %Female= 59%.	We probe opportunities for facilitating family support with TableChat, a chat-based mobile application for food journaling.	Table Chat App, 12 Days	Survey (n=158), Field deployment (n=31).
2018	Honary, M., Bell, B. T., Clinch, S., Wild, S. E., & McNaney, R.	Understanding the role of healthy eating and fitness mobile apps in the formation of maladaptive eating and exercise behaviors in young people	JMIR Mhealth Uhealth	N=114 18-25 years %Female= 35%	The aim of this study was to identify potential risks around healthy eating and fitness app use and negative experience and behavior formation among young people and to inform the understanding around how current commercial healthy eating and fitness apps on the market may, or may not, be exasperating such behaviors.	Users reported on current or past experience of using healthy eating and fitness apps.	survey (n=106) (63 male and 32 female), 2 workshops (n=8)(all female), interviews with experts (n=3), Review of the top 100 healthy eating and fitness apps on the Google Play Store.
2019	Lancaster, R., Radd-Vagenas, S.,	Electronic food records among middle-aged and	Nutrition & Dietetics	N=48, 55-75 years, %female=68%	We compared self-reported and dietitian-adjusted	Research Food Diary App,	Intake record comparison,

	Fiatarone Singh, M., Noble, Y., Daniel, K., Mavros, Y., Sachdev, P.S., Lautenschlager N., Cox, K., Brodaty, H., O'Leary, F., Flood, V.M.	older people: A comparison of self-reported and Dietitian-assisted information			dietary intake records among adults aged 55 to 75 years using the Research Food Diary(RFD) app.	3-days	Field deployment (n=48), Follow up interview
2017	Lee, H. E., & Cho, J.	What Motivates Users to Continue Using Diet and Fitness Apps? Application of the Uses and Gratifications Approach	Health Communication	N=142, % Female = 78.2% Average age 22.7 years	This study explored how the gratifications obtained from the use of diet and fitness apps may motivate users to continue their use of these apps.	Users reported on current or past experience of using healthy eating and fitness apps	Survey
2019	Srinivas, P., Bodke, K., Ofner, S., Keith, N. R., Tu, W., & Clark, D. O.	Context-sensitive ecological momentary assessment: Application of user-centered design for improving user satisfaction and engagement during self-report	JMIR Mhealth Uhealth	N=60 35-64 years %female = 100% BMI ≥ 30	This study aimed to report a case study involving the design and evaluation of a mobile EMA tool that supports context-sensitive EMA-reporting of location and social situations accompanying eating and sedentary behavior	Ecological momentary assessment App. Phase 1: 4 weeks Phase 2: 4 weeks	Phase 1 & 2: Iterative, user-centered design process, (n=11) Phase 3: A single-arm feasibility field trial (n=21), Phase 4: Randomized trial (n=38)
2020	Wei, J., Vinnikova, A., Lu, L., & Xu, J.	Understanding and Predicting the Adoption of Fitness Mobile Apps: Evidence from China	Health Communication	N=8840, %Female = 74.55%	What are the factors affecting users' adoption and usage behaviors on a specific fitness app?	Boohee App	Questionnaire survey
2014	Tang, J., Abraham, C., Stamp, E., & Greaves, C.	How can weight-loss app designers' best engage and support users? A qualitative investigation	British Journal of Health Psychology	N=19 %female= 47% 18–40 years	To explore adults' perspectives on e-health apps designed specifically for weight control.	Publically available, free app	Interviews

C: All Retrieved Design Recommendations

Publication	Venue	Wording	Design Recommendations
Barbarin , A, et al. (2018).*Toward health information technology that supports overweight/obese women in addressing emotion- and stress-related eating.*	CHI	"Resulting HIT guidelines include"	Based on the above findings, HIT should support a focus on intrinsic, immediate goals that are ascertainable in the short term.
			HIT should leverage existing user desire to achieve goals beyond extrinsic motivations such as losing weight to look thin.
			As suggested by participants, HIT could reframe weight loss in terms of immediate quality of life improvements they would experience by losing smaller increments of weight (e.g., meeting weight requirement to go horseback riding with family members), in terms of habit changes rather than outcomes, and in terms of broader holistic health goals that do not concern weight at all
			Additionally, there should be a focus on building motivation even when it is not present; use of holistic goals might help with this as well.
			Based on the above findings, HIT should help users feel good about themselves and their weight management process.
			Cordeiro et al. shows that food tracking can elicit feelings of shame and judgement [13]; our findings highlight the particular need to avoid this in an ESRE context
			HIT should also mediate meaningful exchange of emotional support between users.
			While previous HCI work shows that users seek social support online to aid in healthy eating [e.g., 10], participants' emphasis on venting and processing emotions with others suggests unique design features for this group, such as a "venting space," where judgement-free, open emotional expression is encouraged.
			In creating such spaces, HIT should extend beyond surface-level exchanges to development of sustained relationship bonds between similarly situated users.
			Although most current HIT designed for weight management does not allow for personalization of the types of encouraging messages users receive, they should allow feature tailoring (e.g., timing, frequency, subject matter, etc.).
			Based on the above findings, HIT should support overweight/obese women who engage in ESRE to be cognizant of their real-time food coping response to stress, as well as understand their behavior over time and change their mindset.
			These findings suggest that HIT should be designed to support users practice real time eating with awareness, as well as to provide deeper insights without relying on users to figure it out on their own.
			Furthermore, HIT should be developed to provide such insights on a range of behaviors.
			As a result, and similar to the perspective articulated by previous researchers [30, 48], it is advisable to focus on how tracking tools can be used effectively in relatively short periods of time to support reflection for enacting and maintaining behavior change.
Bentley, Frank; Tollmar, Konrad. (2013). *The power of mobile notifications to increase*	CHI	Based on our findings, in order for notifications to be the most effective over the long-term, they should be:	Based on our findings, in order for notifications to be the most effective over the long-term, they should be: User Configurable: time and frequency of notifications set by the user

wellbeing logging behavior.			Based on our findings, in order for notifications to be the most effective over the long-term, they should be : Non-interrupting: not ringing or vibrating.
			Based on our findings, in order for notifications to be the most effective over the long-term, they should be: Followed with simple logging: taking action or cancelling the notification should be of similar effort.
Honary, M. (2018). *Understanding the role of healthy eating and fitness mobile apps in the formation of maladaptive eating and exercise behaviors in young people*	JMIR MHealth UHealth	In this study, we offer a set of responsibility guidelines for future researchers, designers, and developers of digital technologies aiming to support healthy eating and fitness behaviors.	Furthermore, our experts highlighted a need for approaches that promote listening to one's own body, and its nutritional needs and physical limitations, rather than becoming reliant on the attainment of what are often arbitrary numerical goals.
			Reframing the way that young people think about eating and exercise, by moving away from language embedded in self-quantification and self-objectification, could be an important first step toward understanding how we might achieve this within future technologies that support healthy eating and fitness
			Future apps that focus more on the intrinsic value of exercise and eating behaviors (eg, how food and exercise makes us feel, how much enjoyment we get from the experience) rather than extrinsic weight loss and appearance could be a powerful tool to supporting healthier attitudes toward food and exercise
			Rather than focusing on temporal reminders to complete a daily task, apps should encourage a process of self-reflection and habit formation.
			Consequently, engaging users in the creation of preplanned statements that mitigate negative feelings such as guilt triggered by not meeting goals might be a useful way of supporting users.
			Reflecting on these points, it is important that future healthy eating and fitness apps not only facilitate creation of a digital connection and communities but also provide tools to encourage social connectivity. This might be through the provision of a space to reflect on their social interactions or by providing them with practical tips and strategies (eg, advance planning for social occasions or integrating healthy eating and fitness activities in people's social lives).
			One possible option for the future app developer would be to consider encouraging more long-term behavior change, rather than focusing on engagement [86].
			Furthermore, given that obsessive engagement with apps may reflect problematic use, apps could provide informative feedback based on usage patterns (eg, frequency of app checking or time spent engaging with app) that might be indicative of problem use. For example, to overcome both the obsession and indeed lack of motivation and boredom, the apps could encourage a period of detox when unusual patterns of use are detected, as part of the gamification model.
			In addition, providing a framework within the app that encourages users to self-reflect on their use patterns and to re-evaluate their goals regularly may help users who might be struggling to re-gain a sense of much needed control.
Lancaster, R, et atl. (2019). *Electronic food*	Nutrition and Dietetics		Incorporation of warning notifications or error codes; to allow and encourage participants to self-

records among middle-aged and older people: A comparison of self-reported and Dietitian-assisted information.		We provide four key recommendations to guide this process.	check entries with missing or excessively large quantities, and for food items requiring more details.
			Familiarisation period; to allow participants time to practice navigating the app, entering new foods/recipes with greater specificity to the database options.
			Improved synchronicity between application software and professional analysis programs (eg, the storage of recipe documents and composition databases used).
			Training in the application of dietetic data cleaning adjustments, using national survey data, as part of the data cleaning process to resolve reporting errors
Lee, H.E., Cho, J. (2017). *What Motivates Users to Continue Using Diet and Fitness Apps? Application of the Uses and Gratifications Approach.*	Health Communication	Based on the findings, recommendations for researchers, practitioners, and developers are provided.	Therefore, in order to encourage continued use, it is recommended for app developers to place serious effort on providing users with more easily understandable information that is based on credible evidence from trustworthy sources. This is necessary for developers so that they may increase the accessibility and reachability of their apps.
			But this is also important because developers further have a responsibility to develop apps that provide regular and reliable assistance to users so that they may sustain their health efforts. As such, the findings point to the important role of app developers
			Nonetheless, this should not divert our attention from the importance of increasing eHealth literacy levels among (potential) health app users. Health and communication researchers as well as practitioners should continue their efforts to promote eHealth literacy, so that health app users may better evaluate the quality and value of the apps they are using (as well as other types of health media and electronic health services), ultimately leading to steady, long-term use, which in turn will help maximize the benefits of app use.
			In conclusion, the findings uphold the need for diet/fitness app developers to provide information that is more user friendly, in terms of being highly credible and comprehensible
			On a practical level, this suggests that developers of diet/ fitness apps should focus their attention on creating and refining the health-oriented functions of the apps. More specifically, app developers, instead of focusing on “fun,” should aim at thoroughly supporting users by providing credible and comprehensible information, features that allow for systematic and convenient recording of diet/fitness activities, as well as features that allow for active sharing of experiences and progress with friends/family who share similar goals.
Lin, Zhiyuan, et al. (2018). *I'll Be Back: On the Multiple Lives of Users of a Mobile Activity Tracking Application.*	WWW	Overall, our research has implications for modeling user re-engagement in health activity tracking applications and has consequences for how notifications, recommendations as well as	Once the user intent is inferred, one could cross-promote app features that support the user’s primary intent (e.g., walking, running, or cardio for users attempting to lose weight).
			Here, one could consider interventions targeted at getting previous users with such intents to re-engage (e.g., notifications or e-mails such as “We saw you have not checked your resting heart rate in a while. It might have changed!”).

		gamification can be used to increase engagement. We also discuss design implications for increasing user engagement in this setting.	Here, one can consider, for example, performance/goal-driven interventions such as “Can you still run a 10k in 53 minutes?” or “Can we help you manage your weight?”
			Lastly, gamification techniques such as badges and rewards could be used to incentivize specific multiple-life behaviors
Lukoff, K, et al. (2018). *TableChat: Mobile food journaling to facilitate family support for healthy eating.*	ACM HCI	We conclude with a framework that illustrates how informatics tools can be designed to complement rather than compete with existing family interactions. Third, we explored design considerations when piggybacking a family informatics system on top of an existing communication tool (in our case, the mobile application WhatsApp Messenger)	Designers of family informatics should survey potential participants to better understand their diverse motivations and to decide which ones to support (or not).
			Designers should carefully consider the tradeoffs of technologies that follow or challenge such gender-informed norms [35]
			For colocated families, the vast majority of interaction happens outside of technology. Designers should therefore take special care to understand existing family routines before designing informatics tools.
			Enable multiple family members to assist in tracking [43]
			Request journaling only for non-shared experiences (e.g., meals eaten apart)
			Support entry of activities (e.g., meals) from different cultures [49]
			Increase the salience of nonactions that contribute to the family’s health goals
			Scaffold feedback in virtual interactions to be positive and constructive
			Avoid replacing personal reminders with system reminders
			Designing family informatics tools requires careful consideration of the existing interactions that form the foundation of family life and the motivations that people have for journaling in the first place.
Srinivas P, et al. (2019). *Context-sensitive ecological momentary assessment: Application of user-centered design for improving user satisfaction and engagement during self-report*	JMIR MHealth UHealth	The specific contributions of this paper are (1) a series of design constraints identified as important to consider and satisfy when designing mobile EMA interfaces, which are personalized to users’ preferences. Our aim in this research was to identify the constraints and design parameters for a mobile EMA system capable of capturing self-report measures of eating and movement behavior coupled with participants’ location and social contexts. Specific to reducing burden while capturing a user response, we suggest designing a system that	From this extensive effort, we suggest that future work attempting to conduct momentary assessments should achieve the following minimum specifications to support increased user engagement: (1) an onboarding process to personalize the times when an assessment is delivered to a participant,
			From this extensive effort, we suggest that future work attempting to conduct momentary assessments should achieve the following minimum specifications to support increased user engagement: (2) a question pruning through passive sensing of device location to present only questions most relevant to a participant’s context,
			From this extensive effort, we suggest that future work attempting to conduct momentary assessments should achieve the following minimum specifications to support increased user engagement: (3) increase participant’s attention with a notification that is prioritized over other app notifications in the receiving device,
			From this extensive effort, we suggest that future work attempting to conduct momentary assessments should achieve the following minimum specifications to support increased user engagement: (4) limit the time window within which a participant can respond to a question to capture situations accompanying a behavior,

			From this extensive effort, we suggest that future work attempting to conduct momentary assessments should achieve the following minimum specifications to support increased user engagement: (5) repeat auditory alerts to remind participants to respond
			Specific to reducing burden while capturing a user response, we suggest designing a system that**: (1) supports tap interaction to record a response**
			Specific to reducing burden while capturing a user response, we suggest designing a system that**:(2) uses simple-worded, direct questions with fewer words that are easier to read and quicker for the participant to understand**
			Specific to reducing burden while capturing a user response, we suggest designing a system that**:(3) has simple response options that are easier to read, quicker for the participant to understand and select from**
			Specific to reducing burden while capturing a user response, we suggest designing a system that**: (4) includes instruction as to whether a participant has to consider each question in the assessment independent of one another while selecting a response.**
Tang, J, et al. (2014) *How can weight-loss app designers' best engage and support users? A qualitative investigation.*	British Journal of Health Psychology	Our findings suggest a series of recommendations for designers of weight loss apps for younger adults	First, such apps should embrace both physical appearance and health-related motivations for app use and should seek to translate such motivation into specific goals.
			Designers should consider helpful app features desirable to users such as an extensive food database, a food scanner and provision of dairies, which can support self-monitoring of eating, calorie intake and affective responses to eating.
			Notifications and reminders can also be helpful and these may serve to reorder goal priorities.
			Online forums and chat rooms can facilitate social facilitation and social support and were found to be helpful by some, but not all, users. Hence, such features should be available, but optional.
			Designers should also consider the importance of user interface design as it determines the functionality, and consequently, usability of an e-health weight loss app.
			Hence, features to support barrier identification and problem-solving could potentially add value to apps that are based on facilitating self-regulation
			However, three other important design features: Affordance (e.g., button shaped features can be pressed), mapping (e.g., expectation of a certain effect if an action is performed) and constraints (e.g., components that don't apply are greyed out) were largely unexplored in our interviews. Nonetheless, designers would be well advised to take account of Norman's recommendations
Wei, J, et al. (2020). *Understanding and Predicting the Adoption of Fitness Mobile Apps: Evidence from China, Health Communication*	Health Communication	App developers should… Information obtained through this research will provide developers with practical knowledge for advancing their technology based on users' needs.	The functionality and content of fitness apps should include more extensive evidence-based strategies used in routine behavioral counseling for weight loss. The potential outcome of these efforts would be that mHealth interventions would become personalized to the users' needs for managing their health (i.e., tailored to each user's lifestyle), rather than providing general, homogenous support to every user

			Future mHealth interventions for weight loss may adopt a social marketing health promotion approach aimed at individual customer understanding and insight
			They could also consider the benchmark criterion of segmentation from social marketing's key benchmark criteria. This would involve working on maximizing the benefits and essential aspects of mobile weight-loss interventions, minimizing the perceived barriers, and segmenting the intervention according to the target group/demographic audience.
			Future diet-related apps should go beyond simple knowledge and general assistance to include assessment, feedback, and individually tailored assistance
			Therefore, fitness apps can be used to enhance self-efficacy by priming behavior activation and reducing the burden of behavior change techniques, such as providing convenient ways to self-monitor, set and update goals, communicate with app support, and access personally relevant information and resources efficiently
			Lastly, developers need to ensure that the private information provided by the users is adequately stored and protected.
			Self-control should be taken into account in the development and design of weight-loss apps because many new technologies can overcome ego depletion and the limited resource of self control to a certain extent, including recordings by the Boohee app.

D: Design Recommendations: Notifications

Paper	**Recommendation**	**Co-occurring codes**
A. Barbarin , A, et al. (2018)	**A10:** Although most current HIT designed for weight management does not allow for personalization of the types of encouraging messages users receive, they should allow feature tailoring (e.g., timing, frequency, subject matter, etc.).	**Code: Technology\Notifications** Code: Strategy\Reducing tracking burden Code: Technology\Personalization
B.Bentley, Frank; Tollmar, Konrad. (2013)	**B1:** Based on our findings, in order for notifications to be the most effective over the long-term, they should be: User Configurable: time and frequency of notifications set by the user	**Code: Technology\Notifications** Code: Technology\Personalization
	B2: Based on our findings, in order for notifications to be the most effective over the long-term, they should be : Non-interrupting: not ringing or vibrating.	**Code: Technology\Notifications**
	B3: Based on our findings, in order for notifications to be the most effective over the long-term, they should be: Followed with simple logging: taking action or cancelling the notification should be of similar effort.	**Code: Technology\Notifications** Code: Strategy\Reducing tracking burden

C.Honary, M. (2018).	**C4**: Rather than focusing on temporal reminders to complete a daily task, apps should encourage a process of self-reflection and habit formation.	**Code: Technology\Notifications** Code: Strategy\Behaviour change Code: Strategy\Reflection
D.Lancaster, R, et al. (2019)	**D1**: Incorporation of warning notifications or error codes; to allow and encourage participants to self-check entries with missing or excessively large quantities, and for food items requiring more details.	**Code: Technology\Notifications**
F.Lin, Zhiyuan, et al. (2018).	**F2:** Here, one could consider interventions targeted at getting previous users with such intents to re-engage (e.g., notifications or e-mails such as "We saw you have not checked your resting heart rate in a while. It might have changed!").	**Code: Technology\Notifications** Code: Motivation\Extrinsic
	F3: Here, one can consider, for example, performance/goal-driven interventions such as "Can you still run a 10k in 53 minutes?" or "Can we help you manage your weight?"	**Code: Technology\Notifications** Code: Motivation\Extrinsic
G. Lukoff, K, et al. (2018).	**G9**: Avoid replacing personal reminders with system reminders	
H. Srinivas P, et al. (2019).	**H3**: From this extensive effort, we suggest that future work attempting to conduct momentary assessments should achieve the following minimum specifications to support increased user engagement: (3) increase participant's attention with a notification that is prioritized over other app notifications in the receiving device,	**Code: Technology\Notifications**
	H4: From this extensive effort, we suggest that future work attempting to conduct momentary assessments should achieve the following minimum specifications to support increased user engagement: (4) limit the time window within which a participant can respond to a question to capture situations accompanying a behaviour,	**Code: Technology\Notifications** Code: Strategy\Reducing tracking burden
	H5: From this extensive effort, we suggest that future work attempting to conduct momentary assessments should achieve the following minimum specifications to support increased user engagement: (5) repeat auditory alerts to remind participants to respond	**Code: Technology\Notifications**
I. Tang, J, et al. (2014)	**I3**: Notifications and reminders can also be helpful and these may serve to reorder goal priorities.	**Code: Technology\Notifications**

E: Codebook

Parent Code	Code Label	Description	Example
Strategy	eHealth literacy	Recommendation pertains to Increasing or supporting the development of skills which	*Health and communication researchers as well as practitioners should continue their efforts to promote eHealth literacy,*

		help users to seek, find, understand and appraise digital health information.	*so that health app users may better evaluate the quality and value of the apps they are using…* (Lee et al. 2017)
	Reflection	Recommendation pertains to strategies, features, or broader support for users reflecting on behaviour, choices or past events.	*In addition, providing a framework within the app that encourages users to self-reflect on their use patterns and to re-evaluate their goals regularly may help users who might be struggling to re-gain a sense of much needed control.* (Honary et al., 2018)
	Localization	Recommendation pertains to the inclusion of locally relevant information within the intervention.	*Support entry of activities (e.g., meals) from different cultures.* (Lukoff et al., 2018)
	Gamification	Recommendation pertains to the application of gamification strategies.	*Gamification techniques such as badges and rewards could be used to incentivize specific multiple-life behaviors.* (Lin et al., 2018)
	Reducing tracking burden	Recommendation pertains to strategies, features and approaches which lower the burden on the user when engaging in food tracking.	*Specific to reducing burden while capturing a user response, we suggest designing a system that:(3) has simple response options that are easier to read, quicker for the participant to understand and select from.* (Srinivas et al., 2019)
	Behaviour change	Recommendation pertains to the application of behaviour change strategies such as goal setting**.**	*It is advisable to focus on how tracking tools can be used effectively in relatively short periods of time to support reflection for enacting and maintaining behavior change.* (Barbarin et al. 2018)
Technology	Privacy	Recommendation pertains to the application of measures to increase users' privacy or highlights privacy issues.	*Developers need to ensure that the private information provided by the users is adequately stored and protected.* (Wei et al., 2017)
	Personalization	Recommendation pertains to the ability to personalize certain aspects of the tracking experience.	*The functionality and content of fitness apps should include more extensive evidence-based strategies used in routine behavioral counseling for weight loss. The potential outcome of these efforts would be that mHealth interventions would become personalized to the users' needs for managing their health (i.e., tailored to each user's lifestyle), rather than providing general, homogenous support to every user.* (Wei et al. 2020)
	Notifications	Recommendation pertains to features which prompt, remind or inform users.	*From this extensive effort, we suggest that future work attempting to conduct momentary assessments should achieve the following minimum specifications to support increased user engagement: (5) repeat auditory alerts to remind participants to respond.* (Srinivas et al., 2019)

Physiological	Health	Recommendation pertains to holistic measures of health. Does not pertain to weight loss.	*Furthermore, our experts highlighted a need for approaches that promote listening to one's own body, and its nutritional needs and physical limitations, rather than becoming reliant on the attainment of what are often arbitrary numerical goals.*(Honary et al., 2018)
	Weight-loss	Recommendation pertains to losing weight or reducing body mass.	*HIT could reframe weight loss in terms of immediate quality of life improvements they would experience by losing smaller increments of weight (e.g., meeting weight requirement to go horseback riding with family members), in terms of habit changes rather than outcomes, and in terms of broader holistic health goals that do not concern weight at all.* (Barbarin et al., 2018)
	Social support	Recommendation pertains to features and strategies which integrate support from a user's social circle.	*Online forums and chat rooms can facilitate social facilitation and social support and were found to be helpful by some, but not all, users. Hence, such features should be available, but optional.* (Tang et al., 2014)
	Emotional well-being	Recommendation pertains to a user's emotional well-being.	*Based on the above findings, HIT should help users feel good about themselves and their weight management process.* (Barbarin et al., 2018)
Motivation	Intrinsic	Recommendation pertains to intrinsically motivating users.	*Based on the above findings, HIT should support a focus on intrinsic, immediate goals that are ascertainable in the short term.* (Barbarin et al., 2018)
	Extrinsic	Recommendation pertains to extrinsically motivating users.	*Here, one can consider, for example, performance/goal-driven interventions such as "Can you still run a 10k in 53 minutes?" or "Can we help you manage your weight?"* (Lin et al., 2018)

Appendix F: Personal Reflection

This semester has been both incredibly rewarding and incredibly challenging. At the beginning of this project, the prospect of working with WUR and their nutrition research department was exciting. My PDP goals included collaborating with others and positioning my research within a larger project, as well as maximizing my opportunities for using WUR's resources. COVID-19 brought my WUR collaboration dreams to a halt when they had to shut down their research due to the close participant contact. I was already deep in understanding the vastness of the food tracking space between my literature benchmarking and my interviews with experts. I had also begun to notice interesting contradictions amongst the published work and advice given by researchers and experts in the fields of mobile food tracking applications. With my plans drastically changed, I

decided that focusing on these contradictions and what they mean for us as a design community would help me accomplish my PDP goals in a different way. Paired with difficult personal circumstances, I had to adjust my expectations of this semester on the fly and make the most out of the situation.

Reworking my PDP to accommodate for an adjusted time frame, I arrived at two main goals for this semester.

1) It was important to me to establish where I could best contribute as a design researcher and to learn some new and translatable skills in preparation for my final master's project.
2) I wanted to learn from the people around me, in particular how to introduce quantitative methods into my traditionally qualitative research approach.

As the semester concludes, I feel that I have accomplished both of my main goals. As a design researcher, I have a newfound interest in our research practices as a design community and critically looking at the value of design recommendations has become something I feel quite passionate about. The research semester has not only taught me how to conduct a research project, but has also opened a door to deeper understanding of the papers I read. I am now able to evaluate the reliability and study design of a paper quite quickly, noticing oversights or limitations and then making a judgement call on how much weight to give the knowledge generated by that paper. Prior to this, I had a tendency to take most published research at face value. This will serve me well for the remainder of my masters degree and beyond.

My goal of learning new and translatable skills in preparation for my final master project has certainly been achieved. After my M1.1 design project, I learnt about the importance of related work and set a goal to delve into the related work earlier in my next project. Well, I may have taken it to the extreme in this project delving very far into the literature rabbit hole. I have had to learn how to take a step back, prioritize and become comfortable with tackling smaller chunks at a time. I have a tendency to want to learn and understand everything there is to know about a topic before diving in, however I have learned in this project that you can also learn a lot while staying afloat in the deep end! I am confident that I can begin my FMP with an efficient overview of the design space, maximizing my time and effort by building on established work (after evaluating it critically and validating it against other work!).

My second goal of learning from the people around me has also been achieved. Max has taught me a lot about quantitative methods, as has understanding the meta-analysis process of systematic reviews. The literature review process meant working with and screening large amounts of data. I have learned a lot about the processes needed to set up such a large scale review, and am more confident in working with data sets of this magnitude. Not only have I learned how to generate quantitative overviews of the data, but I can also now infer interesting insights from the data overviews which I struggled with before. Although not all the methods I have learned made it into my final research paper, I will take them with me going forward.

The most exciting part of this project for me has been knowing that this knowledge will not just end up in an abandoned cloud file somewhere. I will be able to apply the insights I have generated to a project with food tracking apps this summer, as well as share with others who are working within this domain. I will be able to apply what I have learned to make better demonstrators within and beyond the field of mobile based food tracking applications in the future and hopefully, others will too.