

Towards Finding Windows of Opportunity for Ubiquitous Healthy Eating Interventions

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Abstract. Persuasion towards healthier eating decisions is a challenging field of research, depending on various internal and external factors. Recent advances in sensor-enriched mobile devices and wearables enable persuasive techniques to predict and influence people's food decisions. One such technique, just-in-time adaptive interventions (JITAI), provide users with personalized and situation-related content and thus, exploit windows of high user receptiveness for persuasion. This work's aim is to shed light on context characteristics of such windows by analyzing 469 meal decisions as well as relating in-depth interviews on eating behaviour. We derive and describe four interesting windows in which JITAI's could be effective: (1) Lack of Alternatives, (2) Unawareness of Alternatives, (3) Evening Cravings, and (4) Social Pressure. On the basis of these situations, we postulate recommendations for timing and content of JITAI's for healthy eating. We plan to use the findings to implement and evaluate ubiquitous nutrition-supportive interventions in the future.

Keywords: Persuasive Technologies, Just-In-Time Interventions, Context, mHealth, User-Centered Design

1 Introduction

Inadequate diets can increase the risks for diseases such as diabetes, some forms of cancer, and cardiovascular problems [11]. By using computationally powerful smartphones, an increasing number of smaller sensors, affordable consumer health wearables, and machine learning algorithms, advances in proactive persuasive systems in the area of nutrition become possible. In particular, such systems could go beyond recording and evaluating past nutritional behavior [3, 6], and offer on-spot and in-time support towards healthier eating, that is, even before a food choice has been made. The premise is that such, technology-supported, Just-In-Time Adaptive Interventions (JITAI) could proactively offer highly effective support in windows of high user receptiveness [19]. Within persuasive technology, such windows are known as *kairos* - "the brief, decisive moment which marks a turning-point in the life of human beings" [13]. Hence, in the food choice process, the long term vision is that JITAI's could automatically sense user's internal and surrounding factors affecting their food choice and deduce opportune moments, *kairos*, to offer the most effective decision support.

Nutritional science already offers insights into the factors underlying (deliberate) food choices and their interplay [20]. Still, there is a surprising lack of *empirical evidence* regarding the presence of patterns in everyday food-choice situations, and how these

patterns affect the healthiness of the food. For example, at what time or place do people eat? To what extent does this routine enable a healthy nutritional behavior? How do people react to other people cooking them meals they do not like? We could assume that all about-to-eat moments are *kairos*, but what about that birthday cake? If we had this knowledge, we would be able to inform JITAI designers regarding people's *kairos* for food choices. Hence, we offer insights to the answers of following questions:

1. Where and when in the real world are the windows of opportunity for a ubiquitous healthy eating intervention to intervene - and where and when not?
2. How do these windows of opportunity differ regarding their social, spatial, temporal, and environmental context?

To answer these questions, this work contributes the results of an exploratory study evaluating every meal of 14 participants over an 8-day period. We (1) collected 469 food choice moments regarding the participant's environmental and individual context, and (2) had participants reflect in-depth on the reasons and appropriateness of food choices. By using a contextual inquiry data analysis approach, we observe four distinct opportunity windows for healthier food choices and discuss the fit of various JITAI methods.

2 Background & Related Work

B.J. Fogg already highlighted the importance of identifying the right time for suggestions in persuasive technologies to increase the probability that a user performs a suggested action [8]. Intervening at the right moment is especially important in mobile persuasion due to the ubiquity and availability of mobile devices.

A persuasive strategy often used for persuading into healthy nutrition is self-monitoring of food intake [12]. Current apps such as FitBit¹ or MyFitnessPal² rely on this strategy as well. As such, the opportune moment is assumed to be *after* the user had a meal. Hence, the system targets behaviour change *passively* in a long term perspective by reviewing previous behaviour. However, once the food is served, more than 9 out of 10 people will eat the whole content of the plate [22]. In a recent survey [16], users expressed the desire for nutritional interventions to take place *before* a meal has been taken. Moreover, a previous study on *kairos* for smoking interventions has shown the opportune moment to be way before 'bad' behavior occurs [17].

Besides timing, JITAIs also focus on various other internal and external contextual factors, likewise activity level, sleep, heart rate, location, routines etc. As result, JITAIs are to be triggered in moments of user's high receptiveness and intervention's high effectiveness [19]. As recent studies demonstrated, both external [10] and internal [6] contextual information is an important identifier of opportune moments to maximize persuasive technologies' effectiveness. For example, when triggered in an appropriate location, persuasive technologies are more successful [2]. Yet, the context of people's meals and influencing factors on food choice are so multifaceted [20], that they change between and within individuals, with different weekdays, seasons, and events. Thus exists a lack of knowledge on individual differences regarding receptiveness and reactions on eating interventions, which makes it difficult to determine *kairos*.

¹ <https://www.fitbit.com/de/app>

² <https://www.myfitnesspal.com/>

We intend to contribute to closing this gap by exploring *kairos* for eating interventions in *breadth*. We differentiate from previous work by taking one step back and scanning people’s eating routine to identify a gallery of potential *kairos* moments, rather than examining or predicting solely one use case. Moreover, we discuss how the deduced *kairos* differentiate regarding contextual attributes. Finally, we explore the fit of various intervention manners for the found *kairos*. With the data provided in this paper, we aim to support persuasive designers in finding the appropriate time and manner for persuasive technology to provide decision support for every day meal choices.

3 Methodology

3.1 Procedure

The study consisted of two main parts, a self-reporting field study and a post-study interview in order to reflect on the food choices made within the period of the field study. General demographics data was collected throughout a short questionnaire. Participants were rewarded with either a 15€ Amazon voucher or student participation points.

Food Monitoring To simplify the meal reporting process, we implemented a smart-phone application (iOS & Android) similar to [7]. The participant could, by using the app, (1) take a new photo or upload an existing meal photo from the gallery; (2) supplement the photo with contextual information evolving the food choice and finally (3) send the photo along with the information about the context via email to the study designers. The collected contextual data is depicted in Table 1. To sufficiently cover all nuances of moods, we followed a classification of secondary emotions by [18], who divided these among the coordinate axes of intense-mild / pleasant-unpleasant and chose some of all quarters. All input fields were optional, but we encouraged participants to provide data as thoroughly as possible. Participants who had troubles with installing or using the app were given the option to send the meal pictures along the context data via WhatsApp messages. Three participants used this option.

Table 1. Overview of the collected contextual variables in the smartphone food journal app

Contextual variable	Examples of value
Description	Open text-field
Sort of meal	Breakfast, Lunch, Dinner, Snack
Occasion	Regular meal, Family dinner, Business meeting etc.
Location	Home, Work, Restaurant etc.
Number of people present	0, 1-3, 4-6, 7+
Social surroundings	None, Partner, Friends etc.
Activity during meal	None, Watching TV, Phone-call etc.
Level of hunger	5-point Likert scale
Mood before eating	Angry, Sad, Bored, Tired, Happy etc.
Additional information	Open text-field

Post-Study Interview Once the 8-day reporting period was over, we invited the participants to a post-study interview. Initially, we asked the participants about themselves, including questions about the lifestyle change they were going through. We then invited participants to pick up to five pictures of meals they perceive as healthy and up to five pictures of meals they perceive as unhealthy. We stressed several times during the interview that the food choices will not be judged but rather be explored with particular interest on their surrounding context. Following, we encouraged the participants to explain more profoundly the reasoning on why they chose these particular food pictures, going one by one in chronological order. We asked participants whether they would, in retrospect, change something about their choice. Finally, we asked if they could imagine a technology intervention that could have nudged the participant towards a healthier meal, i.e., to encourage a continuance towards making healthy decisions.

3.2 Participants

The study was conducted in Germany. We recruited students or young professional that were undergoing major lifestyle change(s) within the previous year, such as start of studies, new employment, or major exams. As research shows, such transition is a groundbreaking period for young adults, as they start facing the process of making own food choices [1]. As major lifestyle alterations are connected to changes in routine behavior, they likely provide influence on long-lasting behavior changes [15], hopefully in a positive way. Out of sixteen recruited participants, fourteen have sent at least one food picture (four male). We therefore consider only the remaining fourteen as our study participants. The age of participants ranged from 18-32 years, with a mean of 25.7 years (SD = 3.75). Eight participants were exclusively students. Recruiting was accomplished via university mailing lists and a university Facebook group which also includes alumni. To record people's natural eating behaviour, we excluded those who must follow a strict diet for both medical and well-being reasons (i.e. diabetes, heart diseases etc). However, participants with steady nutritional habits or preferences were allowed to participate (i.e. vegetarians, vegans, intolerances etc.).

3.3 Data Analysis

We collected all sent meal pictures and according data into one data source. In order to find recurring patterns within the conducted qualitative interviews, we followed the contextual inquiry method [4]. Each examiner first listened to the recorded interview in order to record key statements. For each food choice labeled by the participant as a healthy or a unhealthy meal (that is, up to ten meals), the examiner wrote down the statements participants have made concerning one of the following topics: (1) the reason(s) why that food choice was made, (2) the reason(s) participants would, or would not, in retrospect, change the chosen food choice, (3) the time ahead of which the food decision was made, and (4) the hypothetical, technological, intervention methods that could have convinced the participant to choose a healthier food choice instead of the selected unhealthy decision, that is, to continue making healthy decisions in similar situations. Each statement covering one single information was written on one sticky-note. The sticky-notes for healthy and unhealthy food choices were differently colored in order to easily differentiate them in an affinity diagram.

To assure a high consensus in the interpretations of both examiners, statements from two of the fourteen interviews were transcribed by both examiners. The interrater-reliability is calculated based on the following metric proposed by [5], since their experimental setup was similar to our approach:

$$\text{coding agreements} \div (\text{coding agreements} + \text{coding disagreements})$$

According to this metric, we achieved a mean reliability of 88% (91,24% + 86,37%) for both interviews. In most cases where the two examiners did not agree, the doubt was whether to count a statement as containing one or two key pieces of information. Although the reliability is not perfect, we concluded that no data would be lost in the process in case only one examiner evaluated the qualitative interviews.

4 Results & Discussion

During the one week study we collected 469 food snaps from the fourteen participants. On average, users sent 33.5 snaps in total ($SD = 10.2$) or 4.2 per day. This correlates nicely with the common perception of three main meals and one or two snacks per day. Since all participants assured that they took a photo of every meal they consumed, we assume the list of meals to be complete.

4.1 Tendencies for Healthy Eating Decisions

Within our data, tendencies can be seen towards factors and situations fostering healthy eating decisions. These include (1) the level of hunger right before consuming a meal, (2) the occasion for the eating event, and (3) the reason(s) for eating the particular food.

(1) Level of Hunger

For each meal, the participants were asked about their hunger level ranging from “not hungry at all” to “very hungry” on a 5-point Likert scale. The distribution, as displayed in Table 2, shows that the meals marked as healthy were much less likely to be consumed when (rather) not hungry in comparison to unhealthy meals. Without physiological hunger, the reason for eating lies in other factors, as for example social pressure or cravings.

(2) Occasion of Meal

Within the food monitoring application, the participants had to characterize the occasion of the logged meal as either one or more of the following: (1) regular meal, (2) business meal, (3) meal with family / friends, (4) date, (5) ravenous appetite (craving), or (6) other. As the distribution of occasions displays in Table 3, participants more likely had a healthy meal if it was regularly scheduled, i.e. for breakfast, lunch or dinner. Surprisingly, the number of unhealthy meals resulting from cravings seems oddly low, as one expects



Fig. 1. The resulting affinity diagram of JITAI support methods

Table 2. Level of hunger before a meal categorized by healthy, unhealthy, and all food choices.

Hunger	Healthy	Unhealthy	All
Not hungry at all	0	3	39
Rather not hungry	3	10	46
Neutral	20	23	134
Hungry	28	18	192
Very Hungry	8	8	42

unhealthy meals to happen because of a ravenous appetite rather than regular meals. The follow-up interviews revealed, that the actual occasion of the meals was often indeed the need for a regular meal, but the choice of food was the result of a craving. For example, P3 was hungry and had a schnitzel for lunch. So he marked the schnitzel as a regular meal, although he chose the schnitzel out of a craving.

Table 3. Occasion of a meal categorized by healthy, unhealthy, and all food choices.

Occasion	Healthy	Unhealthy	All
Regular Meal	52	30	237
Ravenous Appetite (Craving)	7	4	47
Meal with Family / Friends	3	14	61

(3) Reasons for Healthy Meals

Eight of the thirteen participants (P1, P2, P3, P7, P11, P12, P13 and P15) stated eating healthy because of **preparation** in advance (in 15 situations). The situations ranged from lunch, dinners and snacks, and were consumed at home, at work, or on a trip, at various times with various people. All but one were regular meals and 7 out of 15 meals happened when the participants were (very) hungry.

Another similar reason to choose a meal is because it was in stock at home. Therefore, all but one of the twelve healthy meals classified as **in stock** were also consumed at home. In eight cases the participants were relaxed, eating either alone, with a partner, or family. All but two meals were regular lunch or dinner (one breakfast & one snack).

Three participants (P2, P8, P13) stated **exercise** as the reason for their food choices. For example, P8 stated she adapts her breakfast in terms of fats and proteins on the days she exercises, preferring almond and banana milk. In opposite to P8, P3 stated to have routinized his breakfast, eating cereals with cream cheese, eggs, water, and coffee every day. Moreover, P4 and P6 classified their breakfast as **routine** meals at home or at work, all of them being very hungry at the time of the meal.

4.2 Tendencies for Unhealthy Eating Decisions

Contrary to the factors fostering healthy eating decisions, the following circumstances can contribute to an unhealthy eating decision.

(1) Meal of the day

When looking at the distribution of the meal categories (breakfast, lunch, dinner, snack), the "snack"-category covers interesting remarks. Only six snacks were marked as a healthy food choice, opposed to 22 unhealthy ones. In ten of 22 unhealthy snacks, the consumption followed a desire for that particular food. From those ten, only two were no sugar cravings. Seven out of ten eating events occurred after 5 pm. In 19 snack cases, participants' hunger level was neutral or lower. Seven snacks were connected to a feeling of fatigue/sleepiness, three during late afternoons and the others in the evening.

(2) Reasons for unhealthy meals

Participants stated various explanations regarding reasons for their unhealthy food choices. One food choice could have been justified with more than one reason.

We called one heavily advertised reason **appetite & desire**, stated by eleven participants (P1, P2, P3, P4, P5, P6, P8, P9, P11, P12, P13, P15). In total, nineteen unhealthy food choices were the result of a craving. The food consumed ranged from chocolate, to pizza, cake, burger, gummibears or schnitzel. This aligns well with the nutritional body of research stating that the energy density of foods craved was more than twice as high as food consumed as regular meal [9]. In ten out of these 19 cases, the meals were classified as snacks and in eleven cases the level of hunger was described as "neutral". The situations in which these cravings occurred were very diverse regarding location, occasion, number of people present etc. In six meals, participants stated that the food happened to be there and available (at home). Time-wise, seven out of these nineteen meals based on desire happened before 5pm, two before 1pm.

Another reason for unhealthy food choices stated frequently (twelve times) by the participants was **social pressure**. In these situations the participants were accompanied by at least one and max three other people which were either partner, friend(s), or family members. Additionally, social pressure includes cases in which food was cooked for the participant and they felt uncomfortable to reject the food (three occurrences). Similar to the meals chosen by desire, only two of these meals were consumed before 3pm. In eight cases the participants consumed the meal at home and in all but three situations they experienced only positive emotions like happiness and relaxation. Likewise, participants engaged in unhealthy meals out of time-saving/practical-to-prepare food motives. Six out of eight times, participants were alone, evenly during lunch and dinner.

We find worth mentioning that five unhealthy occurrences were consequences of a **shortage of healthy alternatives** in the participant's immediate surrounding. All of these occurred while the participant was away from home. Two incidents happened as result of hunger prevention, that is, participants claimed that they were not hungry at that point in time but assumed hunger in a moment when no food would be available. Other reasons were less popular, for example, P5 and P13 stated she likes trying new food out of **curiosity**. If the food is something they are interested in and want to try, it does not matter if it is healthy or unhealthy. P1 and P8 named **boredom** as a reason to eat chocolate while watching TV.

4.3 Food Choice Timing

We classified the answers to the question: "How long in advance have you decided to eat that particular food?", into three time categories, according to the time distance between the food decision and the actual eating event. Food decisions made less than 30 minutes

before were categorized as spontaneous. Additional categories included decisions made within the same day of the eating event, that is, one or more days ahead respectively.

Unsurprisingly, the further ahead the meals were planned, the higher was the fraction of healthy food decisions within a certain time category, as shown in Fig. 2. This makes us discuss the timing of a JITAI for healthy food choices. One could assume that the just-in-time in JITAI denotes the time shortly before the eating event. However, if a JITAI could make the user rethink and plan his meals ahead, we could expect an increase of healthier food choices. This way, JITAI's time frame should ideally shift to the earliest moment possible, for example, support the participant already while grocery shopping or even grocery planning.

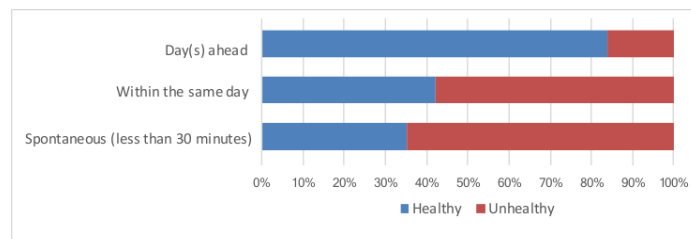


Fig. 2. Food choice decision timing relative to the actual eating event

4.4 Alteration of Food Choice

As expected, participants were happy with their healthy choices in 80% and would not change anything about them. A distribution of all participants' statements on whether they would alter their food choice is displayed in Fig. 3. Within the remaining 20% of healthy choices, participants would have changed the meal because they mostly did not like the taste (4 instances) or because the food amount was insufficient (3 instances). Three healthy meals were labelled as "maybe" to be changed. Participants either perceived the amount of food as too much, or either the meal as unnecessary or the amount of healthy components as insufficient.

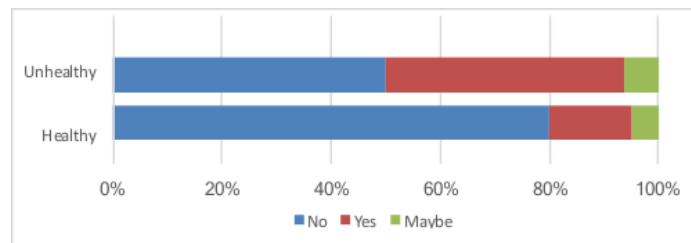


Fig. 3. Participants' statements on whether they would change their food choices in retrospect.

Within unhealthy meals, participants claimed that in 31 out of 62 unhealthy labeled food choices, they would not opt for any meal alteration. The reasons for these claims include self-made, conscious decisions to indulge in unhealthy meals, routine, lack of time, and social pressure. In four cases participants hesitated to modify the unhealthy food choice. Two stated further explanation: (1) if more information at that particular moment was available, the participant would not have taken the food whereas the other person stated that (2) the amount could have been reduced. On the other hand, participants expressed the desire to alter something in 27 food choices. In seven cases, the meal was marked as unnecessary. Four meals should have been substituted with a healthier alternative. A caloric reduction was mentioned three times. The remaining three modifications included an increase of healthier foods in the meal, better planning, and more information respectively.

5 Summary of Contextual Situations & Recommendations for Intervention Methods

In each following subsection, we discuss a *kairos* that emerged as a JITAI's window of opportunity from our observation. We back these up with anecdotal evidence from the interviews (quotes are translated to English when necessary) and examine the fit of intervention methods suggested from the participants.

Kairos 1: Lack of (Practical) Alternatives in Immediate Surroundings According to comments of participants, unhealthy food decisions were likely to occur in situations without healthy alternatives in their immediate surroundings. For example, P1 named at least two situations where she was home eating chocolate and gummibears after 8 pm because “[*They were*] just there”. P12 recalled a frozen pizza consumption at 10:26 pm: “[*The pizza*] was just there for such cases [*of late dinner*] and it is easily prepared in no time”. P15 recalls a Sunday afternoon on which he was really hungry and decided to eat a big Subway sandwich as “the next best thing”, since the usual bakery where he could have gotten a bun and salad was closed.

All three participants proposed a planning tool as their favoured JITAI method. If the tool could automatically detect events ahead, by for example syncing with the participant's calendar, it could propose healthier evening snacks (in case of P1's situation), more diverse food (P12) or just prompt the user that no shops will be working on certain days (P15). It is to be noted, that in Munich most grocery shops close after 8pm Mon-Sat and Sunday all day. When planned right, eight out of thirteen participants stated eating healthy because of preparation in advance (15 situations). Unsurprisingly, the further ahead the meals were planned, the higher was the fraction of healthy food decisions (>80% vs. 35% healthy meals when planned day(s) ahead vs. less than 30 minutes). This data backs up the participants desire for a planning ahead tool.

Kairos 2: Unawareness of Alternatives in Immediate Surroundings Although our participants preferred eating at home (almost 60% of all reported eating events had home as location), sometimes they had meals at other locations. Five unhealthy food choice occurrences were consequences of a shortage of healthy alternatives when our participants were away from home. More precisely, participants P2, P11, P13 and P15

all stated having an unhealthy meal in eating situations around unknown locations. For example, P13 implied: *“It was already after 8pm, [shops were closed] and I just looked around the main train station where I could get something to eat [...] and I decided to take a noodle box which was relatively cheap and easily accessible.”*

All participants wished for a JITAI that displays eating opportunities around the unknown location beforehand. P2 could have benefited from more information the day before, as he wanted to be more prepared when deciding where to eat with colleagues. P11 would prefer an intervention right before making a decision on where to eat: *“I was in a [pizza] restaurant ... in itself I do not like to go to the pizzeria but I did not have so much choice around [that area].* For P13, it is important that the suggestions accustom her taste preferences and include places all along her way to home from work.

Kairos 3: Spontaneous Cravings as Snack in the Evenings Cravings were a reason perceived as responsible for nineteen unhealthy food choices. Even though participants were not hungry, they still snacked, majorly in the evenings (12 were after 5pm). For example, P8 stated for a snack at 7 pm that she *“was bored and then the cookie came to my mind and it did not go away [from my mind] anymore.”* P15 similarly recounted a situation when he came home around 6 pm and had his *“most unnecessary meal of the whole week, because I knew I was meeting friends for dinner in less than 3 hours [...], a frozen pizza”*. P15 added that the meal was not based on a desire for pizza, but rather a craving for food in general.

Eleven participants claimed they would have changed something about an unhealthy food choice rooted in cravings. Participants articulated hunger re-examination as a desirable intervention method. P4, P8, P11 and P15, all desired a system that could detect a craving and pop a question whether that food really is necessary at that moment. P11 was more extreme, describing a system that would lock her ‘stack’ of unhealthy food and make it inaccessible. P3, P5, P11 and P13 proposed an intervention with the aim of calorie reduction, that is, a food saturation predictor. However, in 7 out of 19 unhealthy food choices, participants would not have changed anything. As P2 stated: *“A pizza [or something similar] from time to time is not wrong”* and P1 and P13 complemented an unhealthy meal as reward for good behavior. An ideal JITAI would, therefore, be able to detect the craving as well as its ineffectiveness and therefore, decide not to intervene.

Kairos 4: Social Pressure in Various Situations Social pressure has been recognized twelve times as a stimulus towards unhealthy food choices. For example, in the three cases other people have cooked for our participants, participants were mostly not willing to pursue anything out of social stigma or time saving reasons. Both P11 and P4 assumed a JITAI to be of no help in such situation. On the other hand, P8 and P15 observed that they tend to eat more when in company. Therefore, a proper JITAI could provoke self-control measures by evoking personal goals or, more drastically, predict food saturation. It could state when the participant had enough for the aim of food intake reduction. Yet participants are sometimes also fine with consuming more food in company (P5).

Sometimes, food is a reason for gathering of friends and family. P8 considered a JITAI, that suggests healthier alternatives to coffee and sweets when meeting friends and family, as probably useful. However, she emphasized the importance of a *“decent alternative for coffee and cake, and not exactly an apple.”* Finally, even though she was aware the coffee and cake she had were unhealthy, she would not have altered anything

in her choice. In eight out of twelve cases, our participants experienced only positive emotions like happiness and relaxation. JITAI designers therefore have to carefully design the JITAI in order to not harm such positive emotions and strengthen negative ones.

6 Limitations

Although self-report is a common approach for gathering information on eating behaviour, self-reported data can be (1) inaccurate, (2) influenced by recall bias [14] or (3) influenced by social desirability [21]. We did however stress the importance of a complete dataset as well as our position as neutral and not-judgmental observers. We also asked the participants for their honesty in regards to the correct and complete data we received from them. In addition, participants were asked in the interviews to choose each five rather healthy and unhealthy meals. We therefore cannot assure if these meals were actually healthy, but we did not want to put unnecessary "judgmental" pressure.

Moreover, confusion may have appeared with the participants regarding the terminology of the questions, leading to confusion especially when deciding the meal category and occasion as outlined in 4.2 (1). In many cases, meals had both purposes, namely, to (1) reduce hunger as a regular meal does and (2) fulfill a craving.

To conclude the limitations, we observe that our results may not generalize due to the rather homogeneous study sample and 8-day study duration. Still, we are confident that our exploration gives directions for future work on proactive persuasive technologies.

7 Conclusions & Future Work

We performed an exploratory approach towards finding windows of opportunity for proactive persuasive technologies, that is, JITAIs encouraging healthy eating behaviors. Within a collection of 469 food choice moments from 14 participants and in-depth reflections on the participants' reasons and appropriateness of food choices, we examined the broadness of real-life eating events and their contextual fit for healthy eating JITAIs. As result, we deduced four windows of opportunity (i.e. *kairos*), with potentially high JITAI effectiveness. We discussed how these windows distinguish themselves within their timely, spatial and social characteristics. Furthermore, we collected and mapped a space of intervention techniques to the observed opportunity windows. For future work, we suggest to include additional context factors we discovered during the study such as the emotional value of food (e.g., the cookie for children linked to childhood memories [P5]) and the strength of a craving (e.g., would a person walk all the way to the next store just to get chocolate?). In addition, further differentiation between appetizer, regular meal, and dessert might be helpful. All factors could be good indicators for people's willingness to withhold or indulge their cravings. An additional point for future work would be to investigate how *kairos* differs regarding people's short-term (eg. emotions) and long-term (eg. character, social background) personal characteristics.

In general, we find that in particular designers of persuasive technologies can benefit from the observed information. Within our research, we plan to use the findings to implement and evaluate ubiquitous nutrition-supportive interventions using current mobile and sensor technology. We hope to evaluate the JITAIs' success within changing nutritional behavior across a diverse population in the future.

References

1. Baker, S.: College cuisine makes mother cringe. *American Demographics* 13, 10–11 (1991)
2. Basten, F., Ham, J., Midden, C., Gamberini, L., Spagnolli, A.: Does trigger location matter? the influence of localization and motivation on the persuasiveness of mobile purchase recommendations. In: *Persuasive Technology Conference*. pp. 121–132. Springer (2015)
3. Bentley, F., Tollmar, K., Stephenson, P., Levy, L., Jones, B., Robertson, S., Price, E., Catrambone, R., Wilson, J.: Health mashups: Presenting statistical patterns between wellbeing data and context in natural language to promote behavior change. *TOCHI* 13 20(5), 30 (2013)
4. Beyer, H., Holtzblatt, K.: *Contextual design: defining customer-centered systems* (1997)
5. Campbell, J.L., Quincy, C., Osserman, J., Pedersen, O.K.: Coding in-depth semistructured interviews: Problems of unitization and intercoder reliability and agreement. *Sociological Methods & Research* 42(3), 294–320 (2013)
6. Carroll, E.A., Czerwinski, M., Roseway, A., Kapoor, A., Johns, P., Rowan, K., Schraefel, M.: Food and mood: Just-in-time support for emotional eating. In: *Proc. ACII'13*. pp. 252–257. IEEE (2013)
7. Cordeiro, F., Bales, E., Cherry, E., Fogarty, J.: Rethinking the mobile food journal: Exploring opportunities for lightweight photo-based capture. In: *Proc. CHI'15*. ACM (2015)
8. Fogg, B.: *Persuasive Technology: Using Computers to Change what We Think and Do*. Interactive Technologies Series
9. Gilhooly, C., Das, S., Golden, J., McCrory, M., Dallal, G., Saltzman, E., Kramer, F., Roberts, S.: Food cravings and energy regulation: the characteristics of craved foods and their relationship with eating behaviors and weight change during 6 months of dietary energy restriction. *International Journal of Obesity* 31(12), 1849–1858 (2007)
10. Ham, J., van Schendel, J., Koldijk, S., Demerouti, E.: Finding kairos: The influence of context-based timing on compliance with well-being triggers. In: *International Workshop on Symbiotic Interaction*. pp. 89–101. Springer (2016)
11. International, W.C.R.F.: *The link between food, nutrition, diet and non-communicable diseases* (2014), www.wcrf.org/sites/default/files/PPA_NCD_Alliance_Nutrition.pdf
12. Lehto, T., Oinas-Kukkonen, H.: Persuasive features in six weight loss websites: A qualitative evaluation. In: *Persuasive Technology Conference*. pp. 162–173. Springer (2010)
13. Panofsky, E.: *Studies in iconology*. New York 198 (1962)
14. Paulhus, D.L., Vazire, S.: The self-report method. *Handbook of research methods in personality psychology* 1, 224–239 (2007)
15. Prochaska, J.O.: *Transtheoretical Model of Behavior Change*, pp. 1997–2000. Springer New York, New York, NY (2013)
16. Rahman, T., Czerwinski, M., Gilad-Bachrach, R., Johns, P.: Predicting about-to-eat moments for just-in-time eating intervention. In: *Proc. Digital Health'16*. pp. 141–150. ACM (2016)
17. Räisänen, T., Oinas-Kukkonen, H., Pahlila, S.: Finding kairos in quitting smoking: Smokers' perceptions of warning pictures. In: *International Conference on Persuasive Technology*. pp. 254–257. Springer (2008)
18. Russell, J.A.: A circumplex model of affect. *Journal of Personality and Social Psychology* 39(6), 1161–1178 (Dec 1980)
19. Spruijt-Metz, D., Wen, C.K., O'Reilly, G., Li, M., Lee, S., Emken, B., Mitra, U., Annavaram, M., Ragusa, G., Narayanan, S.: Innovations in the use of interactive technology to support weight management. *Current obesity reports* 4(4), 510–519 (2015)
20. Stroebele, N., De Castro, J.M.: Effect of ambience on food intake and food choice. *Nutrition* 20(9), 821–838 (2004)
21. Tourangeau, R., Yan, T.: Sensitive questions in surveys. *Psychological bulletin* 133(5), 859 (2007)
22. Wansink, B., Johnson, K.A.: The clean plate club: about 92% of self-served food is eaten. *International Journal of Obesity* 39(2), 371–374 (2015)