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ORIGINAL PAPER

Designing healthy living support: mobile applications added to hybrid (e)Coach solution

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Abstract Healthy living is an increasingly important topic on the agenda of policy makers. Containment of health care cost through public health and specific prevention programs is seen as a key element of the current social-economic policies in the western world. Mobile health technology holds the promise to make healthy living support more effective than traditional prevention programs. We extended hybrid lifestyle support (web-based and face to face) with smart phone applications. This paper follows a design research cycle. We start from a user needs analysis, proceed to solution analysis, service development and user testing. Interestingly, despite explicit ex ante user needs for mobile App support and despite their appreciation for the apps, the users in our field test discontinued using the apps relatively fast. The eHealth law of attrition appeared to apply here too. Inspired by the user feedback, we propose several design guideline lessons. For the future, we anticipate more personal and intelligent mobile applications for health behavior tracking and feedback, plus an increasing role in health provider processes.

Keywords Mobile application · Lifestyle intervention · Health behaviors · Living lab user test · Service design

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1 Introduction

When looking at our food intakes and health, there are a number of challenges our Western societies face, and increasingly the developing countries as well: cardiovascular disease, obesity, diabetes-2, several cancers, and as of the one underlying causes: 'metabolic syndrome' and 'cardiometabolic risk management'. The latter two concepts highlight the fact that distorted lipid and carbohydrate metabolisms often coincide, and it was estimated that 43 % of people >60 year of age have metabolic syndrome [22]. This may put them at a 4.26-fold risk of death in 11-year follow up compared to healthy men, and they are estimated to have a 3.7-fold risk for coronary artery disease and a 24.5-fold risk to develop diabetes-2 [35]. This increases burdens for the individual, as well as burdens on a societal and employer perspective. It has been estimated that cardiovascular disease leads to 10 additional sick days at work plus 1 month productivity loss while present at work (sickness presenteeism). For diabetes-2 these numbers are: 11 work days and 8 weeks sickness presenteeism [45].

A healthy lifestyle is composed of various elements such as physical activity, stress management, social support and avoiding known disease determinants as smoking and excessive alcohol use [15, 25]. This paper focuses on healthy dietary habits as an important aspect in the prevention of chronic conditions and to avoid their complications.

This paper aims to design and test a 'multi-channel' service concept ([42, 44], Simons [38]) for healthy consumption assistance, where a mobile application (mApp) is added to existing web-based and coach-based support. This design is made in the context of in-company healthy living support, with a majority of participants being at increased risk for developing chronic conditions such as cardio-vascular diseases, diabetes and obesity. These participants also tested mApps for physical activity and stress management [41], which provide an additional reference point for interpreting our user test results for the dietary mApp.

In terms of health motivation and behavioral change, focus points are: 1) education to create awareness and understanding of healthy consumption [37], 2) goal setting and planning (Gollwitzer and Scheran [17]), 3) monitoring based feedback to facilitate and maintain healthy behavior [11]. And in terms of ICT (Information and Communication Technology), the question is if and how to support user needs with mApps that are integrated into existing health coach processes.

The main research question is: How to (e)Support healthy consumption? And given the mApp opportunities that were encountered: How to integrate mApps for this purpose into existing coach processes?

Our subquestions address:

1. How to achieve maximum empowerment, motivation and health behavior improvement for participants using mApp assistance?
2. Which dietary guidelines and recommendations are appropriate to facilitate informed choices of participants for an 'optimal healthy consumption', (what type of design variables the food categories are: e.g. 'more is better', 'less is better', '2 portions/week is optimal')?
3. What are the requirements for successful ICT-support for healthy consumption? (With successful meaning: creating increased adoption of ICT support and improved health behavior).

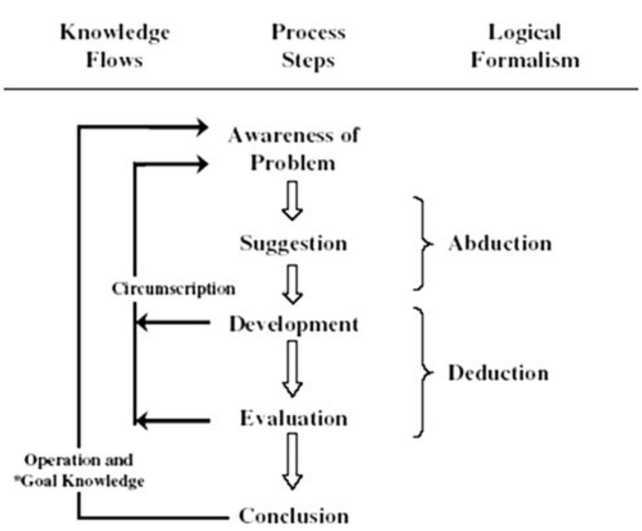

Fig. 1 Design cycle: knowledge creation via design iterations and evaluations (Vaishnavi and Kuechler [47])

2 Theory

In relation to designing healthy living support, we build on the following three areas of expertise, which will be described in the text below:

1. Lifestyle Coaching and motivation
2. Healthy consumption guidelines
3. Designing ICT for health support

2.1 Lifestyle coaching and motivation

Effective healthy lifestyle coaching builds on general motivation theory and on more specific health behavior change models.

Regarding motivation theory, there are a few key elements that we use (see also [39] for a more extensive overview). Firstly, there is the aspect of increasing knowledge and self-efficacy: 'I know where I can make the biggest improvements and I can be effective in reaching goals XYZ' [4, 33]. Secondly, for long term sustainability of health behaviors, it is important to link to intrinsic motivations like feeling better or the joy or positive self-perceptions of taking care of one's health. These types of intrinsic motivations like the joy of feeling good or of mastering a behavior tend to increase the achievements more and be more self-propelling in the long run [12]. Thirdly, it is beneficial to use positive psychology: every step forward counts and should be valued (by the coach and by participants themselves). Fourthly, it helps to let people chose their own goals and their own ways of experimenting with new behaviors: if it is their choice, their commitment and their preferred way of adapting everyday behaviors, the chances grow that the new behaviors will fit in and that there is mental ownership [12, 30]. This also increases robustness: if temporary life events throw people out of their health patterns, the chances that people will restore these patterns later on are larger.

Next, there are specific health behavior change models which provide useful insights. In the HAPA (Health Action Process Approach) model [23, 36] and i-change models [10], three important phases are distinguished. Barriers or motivators for change can reside in each of these phases, which are: awareness, intention, and practice (including coping, experiencing, improving). And as an underlying theme self-efficacy is important in these models: can we support people in developing skills to live more healthily and with tactics to deal with challenges? And if participants have barriers to change, it is useful to address the question in which phase these barriers are located. Are people aware of opportunities to improve and the extent of improvement? Do they have some intentions to change, but they lack specific plans and tactics of where and how to start? Or are there practical barriers: for example, they have started healthy eating, but work or private obligations regarding social eating and drinking are in the way? From a design perspective, these phases represent different types of user support needs. And these support needs must be made explicit during design analysis and solution design [50].

2.2 Healthy consumption guidelines

Our process for defining and using healthy consumption guidelines is as follows. Firstly, our primary focus is on preventing and reversing cardiovascular and metabolic risks; these risk factors have been implicated in cardiovascular disease, obesity, diabetes-2 and some common cancers [26, 34]. Hence they have large health relevance. Secondly, we use recommendations from organizations like WHO (World Health Organization), AHA (American Heart Association), WCRF (World Cancer Research Fund) and the leading nutrition research group from Harvard as a basis. Thirdly, we have to define answers to the everyday questions from our user groups regarding what the optimum food amounts would be for health, even if the answers are not always 100 % clear.

Firstly, cardiovascular disease, obesity and diabetes-2 are the primary targets, given their high incidence and preventability. These are partly related to lifestyle factors like sedentary lifestyle and smoking, and partly to food. For example, about 60–70 % of the large reductions (40–80 %) in cardiovascular disease in Scandinavia over the past few decades can be contributed to smoking cessation plus lowering intakes of saturated fats, cholesterol and 'trans fats' [31]. The latter types of fats are most famous from industrial hardening of oils, but currently the main dietary source of trans fats in Europe is 'ruminant trans fat' which is found in butter, cheese and beef: ruminant animal food products [5].

Secondly, if we look at the trends in dietary advice, it can be observed that naturally fiber-rich foods have gained increasingly prominent roles in the past decades. They are relatively high in micro-nutrients and satiation, in comparison to their caloric density ([49], NHLBI [28]). Thus the advice is to eat more vegetables, fruits, pulses, beans and legumes, more whole grains, more seeds and nuts. On the other hand, sugars and carbohydrates with a high glycemic load are advised to consume sparingly: if replacing fats with high glycemic load carbohydrates then triglycerides go up which increases cardiovascular risk [34]. And diabetes risk is increased significantly [19]. Carbohydrate containing foods with high fiber content and low glycemic load do not appear to have these effects [3, 18, 19, 34]. The 'high glycemic load' problem appears extra significant for people with a sedentary lifestyle and a BMI (Body Mass Index) of 25 or higher [24], which holds true for many people above 45 years old. The problem for this group is that sugars are not absorbed and burned effectively enough: hence they are converted to fats and weight gain [52]. The final group of food substances which are advised to eat only in moderation are [31, 34, 49]: saturated fats, dietary cholesterol and trans fats (whether from industrial or ruminant origin). Cholesterol is only found in animal products, trans fats have increasingly been removed from industrial fats so now fats from dairy, beef and sheep are the main dietary sources in Europe, and saturated fats are also mainly consumed in the form of meats and dairy [5, 31]. Overall, these recommendations point to a more plant-based and fiber-rich food pattern than is the current average [51].

Thirdly, there is the design question: Is there a health optimum for the various foods? Because the healthy consumption guidelines are used within an everyday coaching relationship, we are continuously faced with questions that users ask for various food items: if there is a health optimum? [1] And if there is an ambiguity, many users want to know about it. Moreover they show that they can deal with it.

One type of ambiguity leading to an optimum is caused by the phenomenon of trade-off. Alcohol provides an example: it appears as protective in studies on cardiovascular disease and diabetes-2, but as harmful in relation to cancer risk [48]. Hence, the trade-off guideline is 'up to 2 consumptions per day for men and 1 per day for women' if you are concerned about your heart or diabetes, but less to nothing if your main concern is cancer prevention [26, 48]. A similar trade-off optimum exists for fatty fish. Eating one or two servings per week of fatty fish per week has cardio protective benefits for Western populations. However, pollution with substances like mercury, dioxins and PCB (polychlorinated biphenyl) creates cardiac and nervous system problems [21, 52]. Hence no more than one or two consumptions per week is advised.

Another type of ambiguity is caused by controversy, which hampers a clear optimum definition. An example is low fat dairy. Most Western health organizations (though not the WHO) recommend consuming low fat dairy every day, with osteoporosis prevention as one of the main arguments. In the past, the reason for this position was thought to be simple: consume more calcium to prevent hip- and other fractures. However, it has turned out that this is hard to prove. And some concerns have risen regarding increased ovarian and prostate cancer risks. Hence Willett and Ludwig [51] explicitly oppose the dairy recommendation. Firstly, in international comparisons, countries and regions with more calcium and dairy consumption tend to have higher bone fracture rates (instead of lower). Secondly, also within

[1] These practical user questions are also the reason why the healthy consumption guidelines should preferably aim at foods, and less at chemical compounds [27]

Western populations, like in the Nurses study, no protective relation is found between calcium or dairy consumption and hip or other fractures. On the contrary, above a certain threshold of protein consumption, calcium is extracted from bone tissue to counter protein-induced acidity [52]. The relation between milk and prostate cancer may be linked to the fact that calcium hampers vitamin D activation which is needed for prostate protection. This has been shown for calcium supplements as well as dietary calcium [16]. Another link is IGF-1 (Insulin-resembling Growth Factor-1), which is a significant risk factor for cancers of the prostate and several other sites, and which increases with dairy consumption [32].

Regarding the other foods discussed above, the optimum is of a different nature: regarding vegetables, fruits, pulses, beans and legumes, more whole grains, more seeds and nuts there is a positive dose–response: 'more is better' (within caloric limits). And for sugars, high glycemic load carbohydrates, and fatty meats and dairy there is a negative dose–response: 'less is better'. With these guidelines in the back of their minds, participants can make their own choices, also based on their taste preferences, culinary traditions and other practical considerations. This fits the overall empowerment approach taken in the hybrid (e)Coach program.

2.3 Designing ICT-support for health behaviors

Regarding ICT design, we are in the field of designing 'multi-channel' or 'hybrid' service designs. This means that the designs aim to combine the relative strengths of face to face coaching with ICT-support. The goal is to develop hybrid service concepts which generate more user benefits than purely ICT-based or coach-based solutions alone.

Besides the overall requirement to design services that support the motivation flow outlined in Section 2.1, there are two other levels of analysis. First, what are general guidelines for 'customer-facing' health support applications? And two, what are the relative benefits of the different service delivery channels used (face to face coaching versus web-based versus mobile support)?

First, regarding the adoption on new ICT for health interventions, a large review of e-health projects formulated a number of recommendations/design guidelines [20]. One is to use ICT interfaces which are already used regularly by the user group, for example email or mobile phones (to lower the thresholds for adoption). A second guideline is to be attentive to ease of use: many initiatives in the review showed hampered results because of usability barriers. Thirdly, the applications need to be embedded in a health provider relationship, such that the data capturing and feedback from the applications have a meaningful added value for the users.

Second, what are the relative advantages of different service channels? In a previous evaluation, the relative service experience benefits have been investigated of face to face 'in-clinic' versus web- and phone-based coaching [39]. Face to face 'on site' coaching had as benefits: a closer service experience with the coach, with other participants and with a health focused 'service scape'; group support experiences (obtaining additional social support and co-creating service experiences together; learning from each other; health experiences in healthy food-, sports- and relaxation exercise. And as disadvantages: more (travel) time needed; less flexibility regarding when and where; and not everyone likes group sessions. The coaching that uses the web based dashboard and phone has as benefits: more time-efficient; more flexibility in when and where to have contact; very explicit monitoring of your own progress online; having status reports including 'next steps' commitments always online. And as disadvantages: the sensory-, emotional- and group experiences are more limited. Also, the 'service scape' in which people are immersed is only virtual, not physical. In summary, it was concluded that a hybrid service concept has most to offer. And that user and context specific factors also have an impact on the degree of benefits perceived from either channel.

As a next extension on top of the 'on site' and web based coach services, mobile service elements can be expected to increase closeness (any place, any time) and personalization of support [40]. And an important question is what stimulates continued use of mobile health applications. A number of recent articles confirm the similarities with the general processes of ICT-adoption. Cocosila and Archer [9] showed that perceived risk (financial, psychological, privacy related) has a negative impact on intention to use mobile health support, and that intrinsic motivation is a positive reason for adoption. Akter et al. [1] show that service quality is a construct with strong positive effects on satisfaction, continuance intentions and quality of life. Their service quality construct is composed of the three constructs 'platform quality' (including reliability, efficiency), 'interaction quality' (responsiveness, empathy, assurance) and 'outcome quality' (functional and emotional benefits). Akter et al. [2] show that perceived service quality and perceived trust (also depending on perceived usefulness and on confirmation of expectations) are strong predictors for satisfaction and continuance intentions. Still, on a more specific level of service design, the question remains what constitutes the added usefulness or 'outcome quality' of mobile services on top of face to face and web based services.

A possible form of added usefulness that is discussed by Sultan and Mohan [46] is the ability to adapt day-to-day interactions based on previous usage patterns. Other mobile service benefits mentioned previously [40] are: more extensive data capturing throughout the day to enable more patient empowerment and also care provider empowerment, improved data quality for the health management process, improved feedback options based on improved data, stimulating 'health ownership' by users, supporting health rehabilitation management with the wide available market of 'consumer product' mobile services to support healthy lifestyle, more health data integration at the level of the patient/person involved. It appears that mApp usefulness is often quite context-specific. In this paper we aim at extracting and testing usefulness specifications from an existing health program user base. And we aim to extract design lessons for creating future mHealth designs aiming to improve the balance between perceived usefulness and barriers.

3 Method

Regarding our design research approach, we follow the design cycle of [47]: from problem awareness and solution suggestion to development, evaluation and conclusion. Our research method follows five steps: a) As 'awareness' and 'suggestion' steps: based on user feedback on the previously existing hybrid (e)Health service concept (web-based and coach-based support), what are users needs? b) Define how an mApp addition could contribute to the service concept, and how integration with existing health provider processes should occur. c) As 'development' step: Define and create an mApp extension to the (e)Health solution. d) User tests are conducted for the 'evaluation' step. And e) we then relate the findings to our problem perception and formulate design lessons.

3.1 Case context: Delft University human resource department

This paper is based on the 2011 user experiences from a specific case: (e)Coaching for 101 employees of Delft University selected by the company physicians as eligible for the Health Coach Program which was offered via the HR (Human Resource) department. This is a broad lifestyle support program, using a hybrid solution: eDashboarding to monitor health progress, plus interpersonal coaching in group- and individual sessions. Previously, a design analysis has been conducted in order to identify and use the strengths of the Web-based and face to face service components [39].

The hybrid solution delivered positive results in 2011: $n=81$ of participants were still in the program and available for end of year measurements (average follow up 9 months). Most important for the HR department:75 % of them expressed that they had more energy in the final 3 months than in the 3 months before start of the program; 45 % indicated that they were more productive at work and in their private life; and the average score for 'would you recommend this program' was 8.1 (out of 10). Biologically, there were statistically significant ($p<0.05$) reductions in their risk factors: weight reduction of 2,5 kg to an average of 81,7 kg (95 % Confidence Interval (CI): 1,4–3,6 kg), total cholesterol reduction of 0,28 mmol/l to 5,37 mmol/l (95 % CI: 0,15–0,42 mmol/l), LDL cholesterol reduction of 0,22 mmol/l to 3,32 mmol/l (95 % CI: 0,15–0,32 mmol/l), fasting blood sugar reduction of 0,28 mmol/l to 4,92 mmol/l (95 % CI: 0,14–0,42 mmol/l), systolic blood pressure reduction of 5 mmHg to 129 mmHg (95 % CI: 8–1,7 mmHg) and a diastolic blood pressure reduction of 4 mmHg to 82 mmHg (95 % CI: 6–1,5 mmHg). This occurred with more participants lowering their medication throughout the year than participants increasing their medication. In short, the base level service was judged by the company as good, but the question rose if more health support would be possible with ICT.

The Health Coach Program is also the name of the health support provider, offering these services to other organizations as well. Based on user feedback rounds, the Health Coach Program company decided to explore ICT innovations, including mobile supported food logging.

In the 2011 situation the Health Coach Program used a web based dashboard for weekly logging of physical activity, stress management activities, buddy contact or other social support and food consumption. To limit registration burdens on participants, food assessment was based on one 'average' day per week, with the option to also indicate whether the week also contained non-standard food days or events. Many liked the fact that this approximation approach limited the registration burdens, but others indicated that they would prefer to maintain a complete log on a day-to-day basis.

3.2 Case based design research steps

The design approach for the ICT innovation consisted of the five steps described above. The design decisions in step two to four were conducted by a design team consisting of the HR department client plus two health coaches of the health support provider, using the design approach of Buijs and Valkenburg [7]. The user needs analysis was based on satisfaction surveys after 3 months and at year-end (average follow up of 9 months). In this step, the aim was to focus on needs which are largely solution-independent. In the second step, it was defined by the design team how a mobile application for healthy consumption would be expected to add value. In this phase the decision was made that using best of breed would be better than making. And requirements from the health provider perspective were defined, regarding how to integrate the mApp solution in the existing solutions and processes. In the third step the design team chose one solution from three candidate applications, and this application was integrated in the overall service concept (e-dashboard, individual coaching and group sessions). In the fourth step, the team conducted a design test with 6 users [29] early 2012. This was a real life user test, similar to living lab settings, with participants from three start groups (n=48) that had recently entered the lifestyle program with hybrid support (face to face and web-based dashboard). They were then asked to use the mApp for 2 weeks of dietary intake logging. Afterwards, using semi-structured interviews including 5-point Likert scale questions, their experiences were evaluated. In the fifth step, we extract design lessons in relation to user needs and mApp opportunities.

4 Results

The design process results are grouped in five parts: First obtaining user requirements in the analysis phase, from the 2011 Health Coach Program participants. Second is defining the solution and health provider requirements for integration in existing processes ('suggestion' phase from [47]). The third phase (Section 4.3) is selecting a best of breed mApp according to the requirements, and integrating this into the hybrid (e) coach solution concept for a proof of concept design conducted in 2012. In Section 4.4 we present the user test results. And in Section 4.5 we reflect on similarities with user test results of other healthy living mApps, to extract design lessons for mobile Health.

4.1 Analysis: extracting and defining user requirements

User needs were voiced at two abstraction levels: general needs and ICT-specific needs. The satisfaction surveys conducted for the Delft University human resource department contained a section on main challenges for participants (at 3 months, n=76) and points to improve (at 9 months, n=84). These were remarks in relation to the program in its broadness.

The top 5 answers from users at 3 months when asked for challenges were (n=76): making healthy consumption changes, also in relation to the family (27 %), experienced no challenging issues (24 %), discipline in general (17 %), continuing with sports and everyday physical activity (9 %) and being on time with dashboard progress logging (8 %). The top 5 points for improvement that users mention at year-end is (n=84): Longer and more intensive coaching would have been appreciated (12 %), improving ease of logging with the dashboard (12 %), more focus on physical activity and doing more sports together (9 %), more stress management attention (9 %) and suggestions for using different structures and processes (7 %). (And when looking at the positive feedback, appreciation for the hybrid service concept was confirmed: ways of supporting education, tracking, coaching and using group sessions. But this is outside the focus of this paper.)

In relation to the question of ICT support for healthy consumption, it can be concluded that making and maintaining healthy consumption changes is a challenge (27 %) and improved logging is an issue (8 % and 12 %). When looking at this in more detail, and including the qualitative feedback elicited during group sessions, the following list of user requirements for ICT support additions were collected:

- Complete day-to-day logging of foods consumed
- Logging when 'on the move', not just behind the PC
- Including more extensive food databases, less need to self-insert food items
- Improving ease of use (food entry, remembering preferences and favorite food items)
- Getting positive feedback when above average scores are obtained
- Using smart phone apps
- Reporting which shows foods and nutritional composition per day or week

4.2 Solution definition

Solution definition was conducted in two steps. First, a strategic design direction [7]) was chosen by the design team as explained in Section 3 (whether to use a healthy consumption mobile application, and if so: how?). And next, health provider requirements were defined regarding integration of the solution into existing processes.

The strategic design direction that was chosen was to select and use a 'best in class' mApp for healthy consumption (next to other mApps for physical activity and stress management). The reasons for this choice were a) that about half of the participant population is expected to be smart phone user: not only in the Netherlands [13] but also in this working population, b) that 'use' is better than 'make': this provides more flexibility (another mApp can easily be chosen), is cheaper, and most likely provides better quality to users (popular mApps gain income and scale to further improve themselves), and c) it is possible to select a popular mApp, which has obtained high scores for attractiveness and ease of use, and test it before adopting it.

Interestingly, this choice to select a best of breed mApp opened a playing field where all the top applications were amply provided with useful and easy to use functionality (like remembering preferences, previous entries, bar code scanning of food items etc.). The remaining requirements that were relevant for supporting this user group were:

- Dutch language application, with extensive Dutch foods database
- Price/free app (no cost threshold for participants)
- At least iPhone and Android versions available

Given the choice for this strategic design direction, the integration requirements from the health provider perspective were as follows (in the mApp evaluation of 4.3 these are summarized under ‘reporting fits coach processes’):

– Solution will have to be integrated into existing health coach processes
– Food reports must be present in participant and coach dashboard
– Summary scores based on food logging must be made to monitoring progress

4.3 Development: select and integrate mApp in existing solution

Based on recommendations from existing food App users around us and popularity scores we took the following three apps as our final candidates to choose from: CalorieTeller (from Fatsecret), MyNetDiary (from MyNetDiary.com), and Cal Counter (from MyFitnessPal). In Table 1 these are evaluated using the Pugh method from engineering evaluation. This means that a promising solution is taken as reference point or datum. Next, the other solutions are scored as better (+), worse (−) or same (S) in relation to the datum on all requirements.

From Table 1 it can be observed that CalorieTeller comes out relatively well. It combines international quality standards (some Dutch candidates did not make it to our final three mApps) with extensive support for Dutch food items. Besides, the other ease of use and reporting qualities were sufficient for the Health Coach purposes.

Hence, the next development step was integrating the solution into the hybrid (e)coach solution concept. This was done as follows, supporting regular coach processes:

– In the e-dashboard there are explicit links to the mApps (food and others)
– In the group sessions the mApps are explained
– Food entry fields highlight the mApps entry options
– Food logs and reports from mApp easily linked into dashboard for coach consultation

4.4 User test findings

Of the 48 Health Coach Program participants that were approached, six participants agreed to participate in the mApp user test. This already forms a first interesting finding. Despite previous requests from Health Coach participants relating to mApps and certain functionalities that are provided via the CalorieTeller mApp (see Section 4.1), a large majority of participants declined from participation. Not all of them provided a reason, but several reasons we regularly heard were related to time and timing: ‘now is not convenient, because XYZ’ and ‘I don’t have the time’ and ‘I think the time-investment outweighs the benefits’. This partly reflects the fact that this was an in-company participant group, with many of them having busy schedules. They only adopt activities that they expect to pay off in benefits fast enough.

The test users were asked to use the CalorieTeller mApp regularly and preferably daily throughout the 2 week test period. After 2 weeks they were interviewed, which included the use of 5-point Likert scale questions to capture their opinions on functionality, ease of use and contributions to health readiness, according to the HAPA and i-change models from theory.

The test group consisted of three men and three women, five of them were 50+years old and one was 30+. The all had a liking for trying new ICT (Information and Communication Technology) and they all used mApps regularly.

The functionality offered by the CalorieTeller mApp was generally evaluated by the six test users as useful (many food items in the database, remembering previous entries, providing instant feedback on nutrients, bar code scanning, enabling mobile logging when on the move) and ease of use and attractiveness were also on average appreciated.

Three of the them used the mApp daily (14 times), the others used it three times or less. Only one expected to continue using the mApp. Three users evaluated the CalorieTeller mApp as a useful addition to the hybrid Health Coach Program and two of them indicated that they found it useful to log their dietary intake for a full 2 weeks. As a downside the significant time burden was mentioned by the majority of users.

In terms of health behavior change (HAPA and i-change models, see theory), the mApp mostly contributed to awareness (three users said to have become more aware) and intention (three users reported increased intentions for healthy eating), but less to self-efficacy (only one user

Table 1 mApp Evaluation (via Pugh method); + better than datum, S same as datum, − worse than datum. Scores based on design team evaluation, see also method Section 3

Requirements	CalorieTeller (datum)	MyNetDiary	Cal Counter
Ease of use		S	S
Dutch language and food items		–	–
Price		–	S
Platforms (iPhone and Android)		S	S
Reporting fits coach processes		+	–

agreed that it contributed, three disagreed, two were neutral) or actual health behavior (again one user agreed, three disagreed, two were neutral).

Regarding the technology, we ran into problems with one test participant (too old phone and not enough memory to run the CalorieTeller app), and one other participant had to be helped with some hurdles before CalorieTeller was installed properly. The technological integration of CalorieTeller with the web-based dashboard was kept relatively low tech (e.g. copying a URL that was generated by CalorieTeller into the dashboard that pointed to a food log, to be used in the coach sessions) and largely worked as planned. The practical value for the coach sessions could not really be tested however, due to the limited uptake by the users.

In summary, the CalorieTeller mApp uptake was limited (in relation to the 48 potential candidates) and despite attractive functionality, ease of use and design, the overall added value was perceived as limited by most test users (as well as in 'ex ante' judgment by the group of 48). We reflect on lessons from this finding in the section below.

4.5 Extracting design lessons

In eHealth applications, often the law of attrition applies [14] : after initial use, enthousiasm fades and users drop out in a rapid pace towards participation levels below 10 % of initial levels. We had hoped that the popular CalorieTeller mApp would not follow this fate, due to a) high quality functionality, b) ease of use, c) attractive design, d) use of an existing, everyday communication device (smart phone), e) explicit ex ante user needs as expressed by our target group, see Section 4.1. In other words: high attractiveness and low barriers.

Regarding barriers, we might suspect that the time burdens involved in food logging likely play a role. However, we have reasons to believe this is only part of the story. After the CalorieTeller mApp user test, we also conducted design evaluation user tests (n=8 users) for two other mApps (see also [41]): Runkeeper for tracking physical activity and Pranayama for supporting stress management activities through guided relaxation. For both mApps, the time burdens were considered less significant than for CalorieTeller, but the other patterns of evaluation were very similar to the evaluations for CalorieTeller. Specifically, both Runkeeper and Pranayama were evaluated as attractive (quality of functionality, ease of use, attractive design), their contributions to health behaviors were perceived as residing in the awareness and intention phases, but most test users indicated that after a few times, the added value of the mApp faded for them. This is similar to what we saw in Section 4.4 for the CalorieTeller mApp.

So if the law of attrition also appears to apply to the other two mApps (which cost less time investments, especially Runkeeper), and if users indicate that the added value of all three mApps disappears after a few times ('I know the routine now, the results provide not much news to me'), which mHealth design lessons can we learn?

After reflection on the user feedback, two elements came up. Firstly, part of the attractiveness of an mApp appears to be the 'newness factor': do I learn or experience something new? This can be related to a fun factor ('emotional benefits' [1]), or it can be more functional: do I receive information that is new and relevant for me? In comparison, news-, weather forecast- or traffic jam apps always have new information to offer, hence making continued use attractive. And certain games continue to offer new levels, achievements and experiences. The latter element could be part of Runkeeper use too, but this really depends on the user: if she has entered on a progressive training schedule, progress achievement feedback may become more relevant and rewarding.

Secondly, adopting and using a new mApp, even though it runs on a familiar phone, still introduces a barrier to use. Our users perceived it as learning a new application, and using a new interface. This is not the same as using an existing communication interface, see also the eHealth success guidelines from Section 2.3. This contrasts for example with responding to applications that use email or sms messaging, which is more integrated into daily communication patterns.

In conclusion to the barriers and benefits balance: There are time and attention barriers present when using mApps. Every new mApp appears to constitute a new case of ICT-adoption. Only when the user has entered on a clear path of progression in the healthy lifestyle mApp, and if the mApp offers relevant information that the user did not already know or suspect, there appears to be enough benefit for continued mApp use. And the majority of our test users indicated that after a few times the mApp only confirmed what they already knew about their behaviors.

For future mobile Health support that uses smart phones, we foresee three design challenges. Firstly, if logging can be automated further, with less explicit efforts/actions from users, that does reduce the barriers to use. Secondly, if the use and interfacing can become more automatic and integrated into existing daily communication channels, that would also lower barriers. For example, Bruck et al. [6] report on microlearning modules that push very brief messages to phones (or computers) and that require only one brief 'multiple choice' answer. As suggested by their user experiences, these messages are considered as less burdening than emails. Thirdly, newness and relevance need to be increased. This could for example be done by adding news items, by explicitly using social interactions and support from group members (e.g. social media), or by providing relevant and new details on progress reports (for example improvement of biophysical risk factors, preferably measured non-invasively).

5 Discussion and conclusion

One of the most important opportunities we expect for the future of eHealth is the use of very personal and interactive mobile applications (mApps) for health behavior tracking and feedback. This will include food as part of a broader range of health behaviors (for example physical activity, stress management, quality of sleep, smoking cessation, and social media for social support). It will likely also include increasing levels of biofeedback: some none-invasive (like heart rate measurements) others more invasive (like tracking blood markers), some discrete/occasional (like stress management technique support), some more continuous (like blood sugar variations throughout the day). The design of a generic solution is under way, which allows the combination of relevant parameters for each participant. These values may be extracted from mApps or networked devices already existing (for fitness, for food consumption, a weight scale, a blood pressure measurement device etc.). Beside storage of these data on the local smart phone, replication to the web-based dashboard is assured. Furthermore, access for health coaches or medical specialists may be provided by simply using data containers in cloud infrastructures with appropriate security mechanisms in place. For the implementation a cross-platform approach based on PhoneGap and jQuery will allow broad availability and rapid development.

However, mApps by themselves are likely not enough. When their use is integrated in overall health improvement processes, larger benefits can be expected: on the operational level of behavior change and on the more tactical/strategic levels of using self-perception and social structures for long term healthy lifestyle. On the operational level, as expressed in health behavior change models like i-change and HAPA we expect four benefits: better health awareness and education within a coach relationship (‘awareness phase’, see theory), more explicit planning and reflection on health behaviors with the help of coach (‘intention phase’), more commitment to continue improving health behaviors as a felt reciprocal responsibility towards the efforts of the coach ([8]; ‘practice phase’) and as a consequence: more health behaviors which are learned (‘increased self-efficacy and competence’).

On the more tactical/strategic level of health behavior improvements, we have seen from our user needs analysis several suggestions towards the benefits of ‘not having to do this alone’. Firstly, several users mention ‘discipline and maintaining time and attention’ as one of the challenges for long term health behaviors. So institutionally supporting health behaviors as an employer (with sports facilities, healthy food choices in the canteens, or an active health culture) helps. Secondly, and thirdly, others mention as two potential support forms: ‘by doing this as a group and sharing experiences we support each other’, and ‘by sending around health messages (mail) and having occasional events, we can maintain health awareness and renew health efforts’. Fourthly, participants appreciate the institutional level reports: ‘as a group, we have achieved XYZ in this initiative’. This creates pride and reinforces individual efforts and achievements. In short, besides ICT design (preferably user centered) and health intervention design, we also need institutional design [43]. And an employment setting with an active vitality management from the ‘human capital’ angle appears promising in this regard.

With regard to this design analysis study for healthy consumption using mApp support, several generic design knowledge findings are:

1) Integration of best of breed mApps is easy, flexible, and it can add functionality and quality to health provider processes at virtually no cost. We may be entering a new era of ubiquitous options for enhancing health provider processes with mApps. And it may often be more useful to integrate existing mApps into health provider relationships with clients, than trying to develop one’s own applications. The new elements are that a) it is potentially easy and cheap to adopt (or replace) mApps in health support processes, and that b) it may empower users to the extent that indeed ‘health is what happens between doctors visits’.
2) On the other hand, a new mApp appears to be perceived and adopted like a new ICT application, even though it uses an every-day, familiar interface (the smart phone). Hence email may still be a more ‘pervasive’ and familiar communication channel for many users, than new mApps will be. Further research will have to confirm this hypothesis.

For the future any empowerment of patients as well as continuous monitoring will likely incorporate mobile devices and applications. Currently this development seems in its infancy (e.g. integration across applications, and integration into health provider practices). Still, we see many future opportunities to support healthier living by innovative technologies and raised awareness for the advantages of healthy lifestyles.

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