MULTI-MODE
Deliverable Report (DEL 18433-D05):
Sustainability

Work Package 18433-A1802
Product Launch - Sustainability
1. Introduction

This deliverable report details how to over time sustain an innovative app for assisting with lifestyle changes in the face of cognitive decline. The app Health swipe is built on evidence-based research and there are prospects for wide use, associated with beneficial health effects throughout the user base. This report details the app launch (Section 2) as well as the data back office (Section 3), and the plan for sustaining it (Section 4). All aspects of maintenance and technical support are stated as clearly as possible, so as to make the handover to any future product owner as easy as possible. Midway through the project MULTI-MODE, RISE handed over its rights to further develop the app, commercially or by other means, to KI Innovation, but no assumption about a particular product owner has been made in this report, so as to keep the reporting generic.

This report in particular details the second MULTI-MODE app developed by RISE: Health swipe was just released, while the first app Dementia Risk Tool was publicly released on October 30th, 2017 (Google Play Store) and on December 8th, 2017 (Apple Store). A detailed handbook was an earlier project deliverable (17524-D05). The second app is an extension of the first, rendering Dementia Risk Tool the status of a door opener to the more ambitious Health swipe, even if the former has proven useful in its own right. Dementia Risk Tool computes a risk score while the latter adds prevention by means of suggested lifestyle changes. In Dementia Risk Tool, there is given brief and general feedback, based on the answers that the user provides, towards a risk score. In Health swipe, the work is centred around achieving concrete life-style changes based on the data. The data handled is sensitive and local secure servers are used for the back office software and data. Moreover, the privacy policies have been made GDPR-compliant, with the help of RISE judicial staff, and is available for inspection via permanent links in the apps.

In healthcare, output is the direct measurable effect whereas the outcome denotes the long-lasting implications. Intervention focuses on the output and maintenance on outcome. In other words, the interventions made as a result of app use produce direct effects but the outcome goes way beyond app use. This has important design implications, namely:

1. Lifestyle changes must persist beyond the initial hype and the following normal usage, after which the app is no longer used.
2. Understanding both the user and context is necessary, which requires an adequate design methods, such as user-centred design.
3. Initial motivation must be compared with motivation to sustain a change over time.
4. Available resources for making the change, given the context, must be analysed.
5. The app needs to be part of a likeable system that wins trust over time, and which can only to a limited extent be controlled or even understood.

The above list shows why the work in project MULTI-MODE was not merely about ‘getting an app out there’, but finding the right design for the second app had to be done with clinicians and researchers; a desktop product from RISE simply would not suffice. Therefore the support and critique from the Memory Clinic at Karolinska, provided to RISE by Miia Kivipelto of KI/ARC in the last year of work, is gratefully acknowledged.
If the need arises to detail any aspects of this report, RISE will happily honour its responsibility to assist the product owner. The personal roles assumed for MULTI-MODE are: Krim Talia (business unit manager, Life Sciences), Magnus Boman (innovation lead), Olov Ståhl, Mattias Jacobsson, Fehmi ben Abdessalem (innovation developers).
2. App Design

2.1 Project-Internal Design Phase

The second app development activity started intensely once the first MULTI-MODE app was publicly released in the fall of 2017. Feedback from the initial usage of the first app was analysed continuously. This prompted small revisions and bug fixes of the first app, and also informed the design of the second app. During the earliest internal workshop sessions, some issues were highlighted. First of all, there are already a plethora of existing applications that are centred around lifestyle change. Many of these deal with very specific changes such as diet, exercise, smoking, or memory. Each such app have many years of development behind them and are proven successes (cf. [1] and Figure 1). One early idea was to make one app that simply recommends or curates these more specific apps depending on the identified areas in the first risk-score app. After evaluating this option, it was concluded that it would come with its own challenges and that it would be less interesting than trying out alternative applications with more creative ideas. During one of the workshops, we started fleshing out connections between key MULTI-MODE areas and possible areas of lifestyle changes (Figure 2). One result of this work were the idea of integrating generated templates specifically tailored towards the risk areas found in the first application with a basic task or TODO-app. Inspirational examples in this case were the following apps: Moves, Google Fit, Epic Win, and Productivity Challenge Timer.

![Figure 1: Examples of recent apps that support lifestyle changes and, in the case of Sea Hero Quest, research efforts.](image)

Discussions were also focused on the issue of whether or not goals and targets had to be set with the help of a human coach, to help the user select the proper intervention areas, set realistic goals, provide feedback on activity, etc. Although the feeling was that a coach could certainly be of help to some users, it was decided not to include a coach role in the app, to keep the technical design simple. A user could still seek the help of a coach to create an intervention plan though, but there would be no specific support in the app for coaching (coach logins, coach recommendations, coach feedback, communication between user and coach through the app, etc).
An additional aspect that was discussed was different models for social interaction [2]. This is not something that is trivial to implement, especially not within the scope of MULTI-MODE, but rather something that can be taken into account as it is interesting from a research perspective. Three possible models were contemplated and their analysis informed later design stages:

- Mentorship models - gain points for helping others
- Competitive models - gain points for being best
- Compare to average models - gain points if better than average

Personas were used in the design process to better understand our users’ background and needs, and to make sure that the app would provide different types of users with the right support to help them achieve the needed lifestyle changes (Figure 3). Based on the design elements and personas a number of sketches and wireframes of possible app screens were produced, including interactions and transitions (Figure 4).
Figure 4: Examples of sketches of wireframes and app interfaces. These were later generalised to larger boards which were used in user testing. As a complement to flipping through app pages, user workshops would flip between cardboards, leading to a more transparent and open feedback procedure.
2.2 Requirements Specification and Prototyping

The design of the MULTI-MODE Lifestyle Change app had to adhere to the evidence-based research results [3], and thus came with a number of requirements:

- It should be general, in the sense that the user would have full control over creating milestones, without removing the possibility to deal specifically with the key-areas identified within MULTI-MODE.
- Popular task-driven apps with elements of gamification are well suited for creating goals/milestones/tasks and have the user commit and take action on them, hence the use of gaming metaphors should be investigated.
- Auto-generated milestones from specifically designed templates that directly relate to key-areas identified within MULTI-MODE (e.g., weight, physical activity, blood-pressure,...) should be a feature of the app.
- Completed milestones should map progress onto achievements and badges. Completion of badges would capture distinct lifestyle changes, whereas a subset maps directly to targets identified within MULTI-MODE.

Prototyping then followed, in accordance with the following design strategy, iteratively informed by discussions with researchers and later also clinicians and laypersons.

- Minimalistic design
- Focus on the four themes implied by the FINGER study, possibly enhanced by a fifth that the researchers have subsequently identified as important
  - Physical Activity, Heart, Diet, Social and Cognitive Health
- Involve staff and potential users in small sessions
- Divide themes into chunks of piecemeal change
  - Questions, Information, Actions, Results, Rewards, etc
- Let the user engage in these chunks
- Find hooks into everyday life that is independent of the tool
- Track and visualise progress
- ‘Positivify’ rather than overly gamify

The prototype followed the lessons learned from the first MULTI-MODE app release. The benefits of using the react-native framework together with internationalization provided a stable foundation. A new technical tool in this second round was the ignite framework to better bootstrap consistency and best practices in the development. The development process was agile, with a short build-test-modify cycle at its centre.

Four HOW-questions lie at the heart of the work on preparing the prototype for user testing:

- How do we transfer domain knowledge into actionable end-user content?
- How can we design something that is engaging, persuasive, fun yet lightweight?
- How can we complement existing intervention practices rather than facilitate or replace them?
- How do we make sure that suggested interventions are still based on evidence-based research results?
2.3 The Card Deck Metaphor

In order to deliver enhanced Internet-based multi-modal lifestyle intervention via an app, lots of contemporary user research was studied, completing the picture obtained from KI on the evidence-based research specific to Alzheimer’s and to cognitive decline. In particular, the international trend of scientifically studying Digital Behaviour Change Intervention (DBCI) [3] was adhered to. In DBCI, one does not merely hopes that the user should keep using the app, but also measure her engagement with the app, over time and over tasks. This makes logging of user activity interesting, and the data science that comes with keeping such logs.

For clinical relevance, the strategy was in short to directly involve the clinics (for specification of functionality) and the patients (for evaluation). At Karolinska, the Memory Clinic contributed value to the process through a series of meetings, workshops, and digital exchanges. Much of this process was documented on a shared digital folder at RISE, which was shared with select KI and Imperial College staff. Imperial contributed value through feedback at project meetings and via their user studies. Ulrika Akenine from the Memory Clinic also participated in one of the Imperial focus group studies and gave feedback directly to the app developers at RISE following this.

The general idea adapted to was that the risk score app provided initial information and then the user (possible together with her GP) can decide to move to the intervention step. This step was instrumentalised into five parameters covered by earlier research in the KI-led project FINGER:

1. Physical Exercise
2. Eating Habits
3. Heart Health
4. Social Life
5. Cognitive Health

A maintenance phase then follows, for which the challenge is to keep the new habits, which creates a loop (Figure 5).

![Figure 5: The loop that governs the intervention and its maintenance over time.](image)
The question of how to link all the kinds of information flowing between app and user (Figure 6-8) to the user intervention loop was solved by introducing a card metaphor (Figure 9). Health swipe takes its name from the swiping of cards, which in the app can be done in different directions indicating the user’s trajectory through the exercises and pieces of information that the app provides.

Example: Vitamin D

**Intervention Item**

**Problem:** Patients would benefit from being informed about the health effects of Vitamin D. It has a positive effect on several parameters relevant to dementia prevention since it elevates the mood while encouraging taking a walk outside under the blue sky. The recommendation is safe with respect to external parameters.

**Intended Effect:** Educate about Vitamin D and have the user actively put the information into action.

**Design Sketch:**

![Design Sketch]

**Figure 6:** An example of an intervention item and its mappings to cards. Similar descriptions were made for all intervention items.
Figure 7: Information screens, challenge screen, and quiz card for the Vitamin D intervention item, as the user sees them on an iPhone 8 Plus.
**Figure 8:** Example of an accepted intervention task, resulting in an active challenge for the Vitamin D intervention item. To ‘positivify’ rather than gamify is the key to engaging the user.

**Figure 9:** Mapping onto the user intervention loop via the card metaphor.
3. Data

3.1 Data Collection for the First App

We begin with describing details on the Dementia Risk Tool data collection, in case it needs to be adjusted in the future. The Health swipe app follows the same data collection setup and its configuration will be described in the next subsection.

The server collecting data is a machine located at RISE in Kista, Sweden, and called Zinkbig. It can be reached with the address zinkbig.sics.se (fixed IP 193.10.64.142). The machine is shared with other users at RISE and the availability of resources may vary according to the usage of other users. On that machine, data is handled by an HTTPS server called Nginx, listening on port 443. Nginx handles the security protocol (TLS/SSL) and acts as a reverse proxy. Data is then forwarded locally to a Parse server that handles the request and stores it into a mongoDB database. To start up the system, the commands in green of this section need to be entered in order of appearance.

Firstly, the mongoDB database is launched with the following command, although Zinkbig is configured to launch it on startup:

```
sudo service mongod start
```

Data stored in the database can only be accessed locally by an authorised RISE SICS user. However, to use it from another computer, it is possible for an authorised RISE SICS user to establish an SSH tunnel. It is advised to use the tool Studio 3T and create a new connection with the following settings in both the “Server” and “SSH Tunnel” tabs:

![Studio 3T Connection Settings](image)

The SSH User name (“fehmi” below) and password need to be replaced with the LDAP credentials of the authorised RISE SICS user. Data can then be accessed and exported into different formats (e.g., CSV, JSON).
Secondly, Nginx needs to be configured and launched. Note that Nginx might be used by other projects, so please always manipulate it carefully. It is configured by editing the following file:

```
/usr/local/etc/nginx/nginx.conf
```

In that configuration file, the following block was added to access the parse server and its dashboard through HTTPS:

```
##### MULTIMODE project ######
# fehmi@sics.se
location /parse/ {
    proxy_set_header X-Real-IP $remote_addr;
    proxy_set_header X-Forwarded-For $proxy_add_x_forwarded_for;
    proxy_set_header X-NginX-Proxy true;
    proxy_pass http://localhost:1337/;
    proxy_ssl_session_reuse off;
    proxy_set_header Host $http_host;
    proxy_redirect off;
}
location /dashboard/ {
    proxy_set_header X-Real-IP $remote_addr;
    proxy_set_header X-Forwarded-For $proxy_add_x_forwarded_for;
    proxy_set_header X-NginX-Proxy true;
    proxy_pass http://localhost:4040/dashboard/;
    proxy_ssl_session_reuse off;
    proxy_set_header Host $http_host;
    proxy_redirect off;
}
```

Zinkbig is configured to launch Nginx on startup, but it can be launched manually with the following:

```
sudo service nginx start
```

For maintenance and debugging purposes, all requests to the server are logged in the following files:

```
/var/log/nginx/https_access.log
/var/log/nginx/https_error.log
```
Once the connection is secured by Nginx, data is then forwarded to a Parse Server to be inserted into the mongoDB database. The Parse Server is only listening on localhost on Zinkbig and configured with the following:

**Application ID:** DementiaRiskTool  
**Master Key:** HfsbXgZn0PEhFPF9c3uVKsvdDHIJJyDu  
**port:** 1337  
**host:** localhost  
**databaseURI:** mongodb://localhost/DementiaRiskTool  
**mountPath:** /parse  
**maxUploadSize:** 20mb  
**serverURL:** https://localhost:1337/parse

Zinkbig is configured to launch the Parse Server on startup, but it can be launched manually with the following:

```
/project/multimode/parse-server/parse-server.sh
```

This script has been copied to `/usr/local/etc/rc.d/parse` to be launched on startup.

The Parse Server interacts with the Parse API used by the smartphone app. It can be monitored via a web interface, including the data stored in the database. That web interface is launched on startup by Zinkbig, but it can again be launched manually:

```
/project/multimode/parse-dashboard/parse-dashboard.sh
```

This script has been included into `/usr/local/etc/rc.d/parse` to be launched on startup.

The Web interface is intentionally only accessible from a machine with an IP address belonging to RISE SICS, since access to port 4040 is restricted by the RISE SICS firewall. It can be accessed by any web browser by visiting the following URL:

[https://zinkbig.sics.se:4040/dashboard](https://zinkbig.sics.se:4040/dashboard)  
**Username:** admin  
**Password:** < To access files, code and data, please ask fehmi.ben.abdesslem@ri.se >

All answers given by the app users are securely sent and stored with that system, along with a timestamp. Users are identified with a random identifier generated by the server, to ensure anonymity.
3.2 Data Collection for the Second App

Data collected with Health swipe goes through the same architecture: the connection is handled by Nginx, then forwarded to another local Parse Server, and then stored by that Parse Server to the other MongoDB database, managed by the same MongoDB server. The following Nginx configuration has been added:

```nginx
location /intervention/ {
    proxy_set_header X-Real-IP $remote_addr;
    proxy_set_header X-Forwarded-For $proxy_add_x_forwarded_for;
    proxy_set_header X-NginX-Proxy true;
    proxy_pass http://localhost:1336/parse/;
    proxy_ssl_session_reuse off;
    proxy_set_header Host $http_host;
    proxy_redirect off;
}
```

This additional configuration tells Nginx to listen for HTTPS connections on `https://zinkbig.sics.se/intervention/`, and once secure, to redirect requests to another local parse server listening on port 1336 (instead of 1337 for the parse server handling data for the other first app). That other Parse Server is also launched on startup, and configured in `/usr/local/etc/rc.d/parse` with the following configuration:

**Application ID:** DementiaInterventionTool  
**Master Key:** HfsbXgZn0PEhFPF9c3uVKsDHIYyDv  
**port:** 1336  
**host:** localhost  
**databaseURI:** mongodb://localhost/DementiaInterventionTool  
**mountPath:** /parse  
**maxUploadSize:** 20mb  
**serverURL:** https://localhost:1336/parse

Both the database and the dashboard can be accessed the same way as with the first app, respectively using the same SSH Tunnel, and using a browser pointing at the same address (please refer to the previous subsection):

All cards swiped by the app users are collected, along with their swiped direction, the corresponding answer, and a timestamp. Moreover, the app requires the user to login, using credentials that were given beforehand. Those credentials are created using the dashboard by an authorised RISE user. The collected data always contains the user name of the app user (not shown in the screenshot above), so that we can differentiate data collected from different users. Whenever the app user swipes a card, the app attempts to upload the corresponding data to the server. If the upload attempt fails, e.g. because no Internet connection is available, the answer is stored locally on the phone and tagged as unsent. When the app user swipes another card, the app attempts to upload the new data generated, along with any data stored locally and tagged as unsent.
4. Plan

4.1 Current Status

4.1.1 Market Potential

The market size of Health swipe is enormous. According to a recent Ericsson Mobility Report, 4.9 billion people are subscribers of mobile services with slightly more than 50 per cent connected over a 3G or 4G network using either a smartphone or a device with mobile Internet features [4]. From this basis of about 2.5 billion smartphone users, almost 1 billion is in the age groups where cognitive decline is a serious health issue. It is this billion from which the possible users of Health swipe will be taken. There are no significant deductions to be made regarding genetic factors, as dementia and its associated risks are global.

To the best of our knowledge, there is no competitor offering a validated basis for computing dementia risk scores. The underlying research studies, led by MULTI-MODE lead Miia Kivipelto, constitute a foundation for validation and calculation of risk scores, which are currently being updated and adapted to new age groups [5]. The ongoing expanse of her FINGER project into WORLDWIDE FINGER provides a solid foundation that possibly competing app-developing companies and organisations all lack at this point.

The Health swipe app targets the following groups in order to identify increased risk for dementia, and suggest lifestyle modifications and interventions to reduce the risk for dementia:

1) Middle-aged adults
2) Older adults
3) Patients in memory clinic settings
4) Health professionals in private and public sectors

4.1.2 Academic Interest and Policy Making

Dementia and Alzheimer’s disease have a human, societal, and economic burden with a total annual cost worldwide exceeding $600 billion. As there are currently no disease-modifying drugs available for dementia or Alzheimer’s disease, early risk detection and prevention has been highlighted as a public health priority. While risk reduction and prevention strategies are conducted in research settings, wider implementation is needed, and the eHealth tools developed within MULTI-MODE form an ideal implementation tool for various populations and settings. Non-financial and policy benefits include:

- recognition of the research,
- academic or industry institutes being noted for their innovative work,
- enhanced opportunities to participate in upcoming EU collaborative innovation projects,
- facilitation of participant recruitment into studies,
- benefits to healthcare systems through identification of early dementia risk,
- promotion of prevention programs,
- increased collaborative opportunities with policy makers and other stakeholders,
- increased collaborations with clinical settings, and
- promotion of new start-ups.
4.1.3 Commercial Development

On November 10, 2017, KI/ARC staged a meeting between KI Innovation Office (Matts Ferm et al.), KI researchers, and RISE app developers and innovation lead. At the meeting, KI Innovation showed an interest in taking the apps to market, building on earlier business plans developed with KI/ARC (Shireen Sindi et al.). They therefore asked if RISE were insisting on their intellectual property rights (IPR) to the app and its contents. The reply was negative: RISE did not intend to keep any IPR and also had no intention to push the apps to market; however, RISE declared themselves willing to support KI in any such attempts. This document intends to make any handover or sustained maintenance easy, in keeping with that declaration.

On April 18, 2018, KI/ARC introduced Combinostics to project MULTI-MODE. The project lead Miia Kivepelto had worked with the company before in other projects, and knew they had a product that was relevant to the MULTI-MODE apps. At the meeting, Jyrki Lötjönen presented their personalised tool and it was generally agreed to consider it a possibility that the RISE part of MULTI-MODE could be integrated with Combinostics’ commercial offering somehow. Over a series of discussions and meetings, if and how to best do this were discussed. Jyrki Lötjönen also contributed via feedback and viewpoints on earlier sketches of Health swipe.

4.2 Future Scenarios

There are a number of possible scenarios what could happen to the material and innovations developed by RISE, including:

A. KI Innovation Office takes Health swipe to market
B. Combinostics integrates the functionality of Health swipe into their existing tool set
C. KI and RISE (and possibly others) continue their co-development and innovation work via further joint projects and collaborations
D. A spinout company is created by some of the MULTI-MODE participants to market Health swipe
E. Health swipe remains a non-commercially available app that continues to be developed, driven by one or more clinics, assisted by RISE
F. Health swipe further development is stalled with the end of MULTI-MODE and remains a downloadable app without promotion

It is also imaginable that Health swipe gets a large user base and thus an active community, while in other scenarios it remains an app of a few hundred users. Regardless of which scenario above comes to pass, RISE will honour its maintenance agreement towards the user base. In scenarios A through D, this responsibility will over time move to other parties, while in scenarios E and F, it will remain with RISE until the usage is negligible.

Because many factors determine which of A-F (or even another scenario) will actually come true, this document has offered a description of the development of Health swipe, including the people involved at RISE, plus details on the data back office management. Further details are given in the other deliverables and project documentation, as well as on the Health swipe Web page healthswipe.eu. In addition, there is a huge knowledge repository for the project on Google Drive, most of which is already accessible to all MULTI-MODE participants, and a development account on GitLab, accessible to RISE employees.
References


