

ICY Computer Science
Introduction to Human Computer Interaction
University of Birmingham



Group 48:

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Abstract:

In this project we aim to provide a solution for health conscious people, by producing an application that will provide them with support and guidance regarding their daily eating habits and exercise regimens. The project draws on relevant research regarding behavioural change, persuasive technologies and analysis of mHealth applications. Taking into account how large our user base can be, the final design has been carefully considered and implements multiple customisable features.

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Project definition

Understanding and changing one's habits and tendencies when it comes to weight management is an important part of living a healthy life. With the rise of popularity of different fast food chains and easy-to-cook pre-made meals, the general public is getting more concerned about managing their health and weight alongside enjoying all the available food options. Throughout the years there have been a multitude of different approaches from individual one-to-one advice from dieticians, to support groups like Weight Watchers and various online platforms to help people manage their weight.

The aim of our project is to provide a resource, which would explore the existing habits of a person, provide recommendations on how to change that behaviour in order to improve the overall health of the user (while also aiding with weight management). The resource would provide the person with guidance and support that is easily accessible and available in a user-friendly way.

As our focus when dealing with this problem is ease of access, we have decided to work on a mobile application, as this solution would allow the user to track their progress on a portable device they are likely to have on them most of the time.

The ultimate goal of a user of our system is a sustainable solution to their struggle with maintaining a healthy weight in a healthy way. The primary users of our systems would ideally be people, who are not only concerned about their weight, but also are interested in improving their habits and introducing healthy behaviour into their life. The goal of the users we are catering to living a healthy lifestyle first and the change in their weight (or the maintenance of their current weight) is a result of their efforts to improve their behaviour.

We understand that the group of people we are catering to can be quite large and their preferences and personal goals could differ significantly. Because we are conscious of this, we have decided to implement software, which can be personalised and customised according to the users' needs (e.g. dietary requirements, understanding of weight loss strategies).

In order to better understand how to understand, influence and change user's behaviour, we have decided to look into literature behind behavioural change and what factors influence people to introduce improvements to their behaviour, as well as literature regarding how specific mHealth applications utilise (or do not utilise) these strategies to help the user. As our focus is on healthy and long term improvements we have decided to read upon what encourages users to engage with an application for an extended period of time.

Additionally, we will examine and analyse how effective existing software applications are and consider whether we could draw upon or improve some of their features.

1. Review of Related Work

2.1. Literature Review

Our research is focused on influencing users' behaviour via a persuasive mobile system that encourages long term engagement and the improvement of health related habits in the user. We have drawn relevant empirical research examples and focused on each of the elements of the project. We have identified and review four key pieces of literature in order to understand how we can address behavioural change, persuasive systems, continuous engagement and evidence-based strategies for weight loss.

2.1.1 Implementation of Behaviour Change Techniques

Review of: Michie, Susan., Johnston, Marie., Francis, Jill., Hardeman, Wendy. and Eccles, Martin. 2008. From Theory to Intervention: Mapping Theoretically Derived Behavioural Determinants to Behaviour Change Techniques. *Applied Psychology*, 57(4), pp.660-680.

The first piece of literature '*From Theory to Intervention: Mapping Theoretically Derived Behavioural Determinants to Behaviour Change Techniques.*' (Michie, Johnston et al, 2008) explores the methods used for improving human behavioural patterns in conjunction with an understanding of behavioural determinants. The article identifies the best methods in relation to behavioural determinants. It also provides an understanding of the problems a user faces when attempting to change their behaviour, most influential determinants and best methods used to aid behavioural change, which nurture long term healthy lifestyle behaviours.

Study Overview

This paper explores the methods frequently used to alter human behavioural patterns, and seeks to find connections between these methods and how they affect 'behavioural determinants.' Through a discussion of existing intervention techniques and the shortcomings in the current discipline of intervention planning, the authors aim to provide a more

conclusive and objective study into the effectiveness of behavioural change models. They highlight the problems with loosely basing techniques on ideas of behavioural change and propose a new methodology, encouraging interventions to be designed to target specific 'causal determinants of behavioural change. (Michie, Johnston et al, 2008:662)

The methodology for collecting the research in this study is discussed at great length. Both a list of behavioural determinants as well as behavioural change techniques are gathered from a large range of sources and definitions of each are agreed between several professionals.

In this study a large group of psychologists individually identify each of the methods that can alter human determinants by rating each one against every determinant to evaluate its effectiveness. All results were gathered together outlining the success of each method. For instance, 'Goal' methods that set the patient specific targets of achievement, are excellent for improving the patient's skills, motivation, and action planning. However, they are not good at altering the patients social role, identity within society, social influences, memory, attention and decision processes. After the classification, the researchers analysed which determinants were easily and frequently affected and which ones were harder to adjust and change.

This study focuses on two key principles, behavioural determinants and behavioural change methods. Behavioural determinants or 'key determinants of behavioural change' can be defined as the key elements that affect a human's behaviour. They can be broken down into several categories, including Self-standards, Skills, Self-efficacy, Anticipated outcomes/Attitude, Intention, Environmental constraints and Norms. Self-standards include social identity and professional identity; Self-efficacy involves beliefs about capabilities; Norms include ideas of social influence and emotion norms.

These determinants play a key part in our emotions, how we view ourselves, our views on others, our positive mindset, our capabilities and many other aspects of our mental lives. It is generally understood that these elements play a big part in the decision-making process which in turn affect our behavioural patterns. Consequently, adjusting some of these key elements has a knock-on effect on behaviour and allows for slow but controllable behavioural change in predictable ways.

Behavioural change methods are the methods that have been used and observed to change the behaviour of patients. Importantly, although we are aware that they are affecting our behaviour, we do not know which elements of our behaviour they target. It is important to note that this is not the case for all methods: Some of them have been established techniques for a significant amount of time and have been studied and examined in great detail, while others have only been identified fairly recently.

Key factors

The key factors to take from this study are certain methods that apply nicely to app-based strategies as well as the determinants provided in the study.

a. Behavioural Determinants:

The study identifies the following determinants:

- Social/professional role and identity
- Knowledge
- Skills
- Beliefs about capabilities
- Beliefs about consequences
- Motivation and goals
- Memory, attention and decision processes
- Environmental context and resources
- Social influences
- Emotion
- Action planning

(Michie, Johnston et al, 2008:664)

b. Key behavioural change methods

The following is a shortened version of the data presented in the study, excluding information that is not relevant to mHealth based applications:

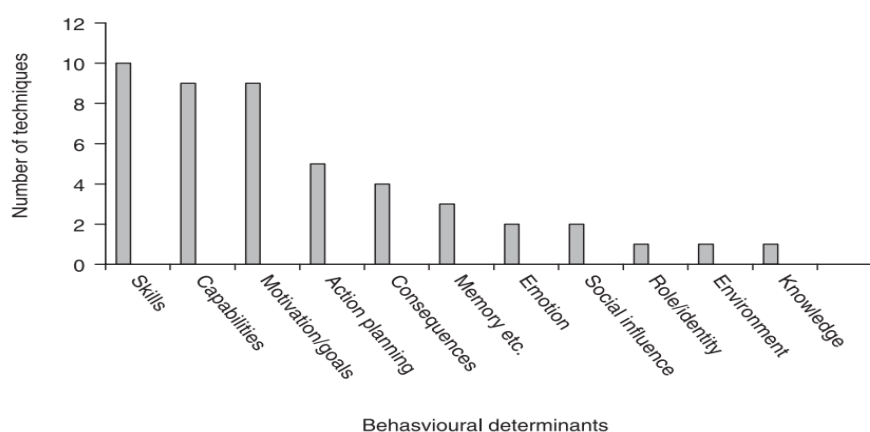
Original technique number	Technique name and description
1.	Goal: set behavioural goal
3.	Monitoring: record specified behaviour (person has access to recorded data of behavioural performance e.g. from diary)
4.	Record antecedents and consequences of behaviour: social and environmental situations and events, emotions, cognitions
5.	Feedback: of monitored (inc. self-monitored) behaviour
6.	Comparison: provide comparative data (cf. standard, person's own past behaviour, others' behaviour)
7.	Social comparison: provide opportunities for social comparison e.g. contests and group learning
10.	Planning: identify component parts of behaviour and make plan to execute each one or consider when and/or where a behaviour will be performed, i.e. schedule behaviours
12.	Goal review: assess extent to which the goal/target behaviour is achieved, identify the factors influencing this and amend goal if appropriate
14.	Prompt: stimulus that elicits behaviour (inc. telephone calls or postal reminders designed to prompt the behaviour)
15.	Reward: contingent valued consequence, i.e. if and only if behaviour is performed (inc. social approval, exc. general non-contingent encouragement or approval)
23.	Instruction: teach new behaviour required for performance of target behaviour (not as part of graded hierarchy or as part of modelling) e.g. give clear instructions
28.	Habit formation: perform same behaviour in same context
36.	Relapse prevention: identify situations that increase the likelihood of the behaviour not being performed and apply coping strategies to those situations
41.	Social support (emotional): others listen, provide empathy and give generalised positive feedback

48.	Time management: action planning applied to the perceived problem of shortage
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(Michie, Johnston et al, 2008:673-678)

c. Most commonly affected determinants

The following graph demonstrates, which determinants were found to be most frequently affected by a particular method, which shows that skills are easily affected but peoples social influences are much harder to adjust.



(Michie, Johnston et al, 2008:668)

d. Additional notes:

Positive vs negative methodology:

The study also has considerable information on methods which are considered ‘negative’ or ‘non-positive’ such as negative reinforcement. The decision to cut such methods out of our edited table is a conscious one. The focus of our design is positive reinforcement that can help the user develop healthy habits in a positive and encouraging manner. While

there are some benefits to negative reinforcement, this methodology, when tied to health and weight has the potential to be detrimental and damaging to one's mental health.

e. Problems or shortcomings

The main shortcoming of this study as identified by the original authors is its lack of conclusivity. They admit that the process of classifying all of the methods identified is one that will need to happen in stages. They identified a total of 136 methods in this first study, however, only defined and classified 53 of these. The results are therefore lacking in considerable data and should not be considered conclusive in any way. The results in mapping the methods onto the determinants also had mixed success when bringing data together from all professionals. In total there was a 71% agreement in classification. However, when breaking down the data into smaller cells, 77% of the cells were classified as uncertain due to inconclusive results from all of the professional's classifications.

Another flaw in the paper is the grouping of methods in the categorisation table. The researchers provide no explanation regarding the decision to group methods, leaving it unclear why some are methods grouped and others are not.

2.1.2. How persuasive systems can influence behavioural change

Review of: Oinas-Kukkonen, Harri and Harjumaa, Marja. 2009. Persuasive Systems Design: Key Issues, Process Model, and System Features, *Communications of the Association for Information Systems*, 24

The second piece of literature we have examined is in regards to the development of persuasive systems. 'Persuasive Systems Design: Key Issues, Process Model, and System Features' (Oinas-Kukkonen and Harjumaa, 2009) suggests seven underlying postulates for

persuasive system design and develops twenty eight principles for persuasive system design based on these postulates. The paper defines a set of principles for the design of systems that can alter user behaviour and attitudes.

Study Overview

This article is based on empirical research and aims to formulate theoretical constructs and principles for what it calls ‘Persuasive Systems Design (PSD).’ Persuasive Systems Design is defined by the authors as the deliberate use of technology design to ‘change users’ attitudes or behaviour or both.’ The principles the article produces are based on the seven ‘underlying postulates’ of PSD.

The 7 ‘postulates’ of PSD

The article describes the process for PSD in a simplified form at the start of the article, using the diagram below. It categorises the seven postulates for PSD as the ‘understanding key issues’ stage:

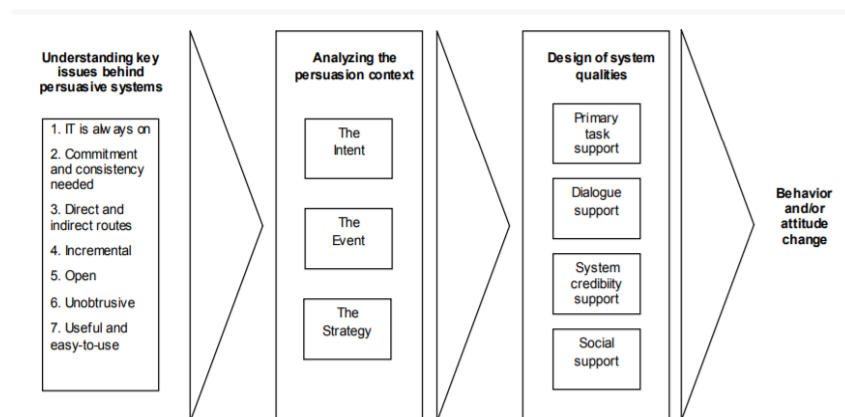


Figure 1. Phases in Persuasive Systems Development

a. ‘IT is always on’

Technology is constantly influencing its users and is never neutral. The users are ‘constantly being persuaded in a manner similar to how teachers persuade students in schools.’ A system should adapt to any changes in the user’s expectations and maximise its persuasive effect continuously.

b. For technology to be persuasive, the user has to be committed and consistent(Cialdini et al, 1981).

According to this paper, commitment makes users more likely to follow through on new behaviours. A persuasive technology should find a way to facilitate commitment making (e.g exercise planning or buying gym memberships). Consistency in this instance means the consistency of a users attitudes with their behaviour. Over time attitudes will adapt to new behaviour (to which the user has committed) and consistency will be created between attitudes and behaviour. To this end, commitment enables a technology to become persuasive.

c. 'Direct and indirect routes are key persuasion strategies'

Users, who consider arguments for new behaviour carefully are more likely to be persuaded by direct routes of persuasion, such as relevant articles being presented to them. Users, who are not highly engaged with arguments for new behaviour (for reasons of disinterest, lack of time or 'information overflow') are likely to rely on indirect routes, responding better to heuristics or 'cognitive shortcuts.' To this end, overt persuasive techniques should be restricted to situations where they are more likely to be willing to respond to them, such as when browsing a social feature (lack of time constraint) or actively searching for information (and as such showing a willingness to engage with new information and change behaviours).

d. 'Persuasion is often incremental'

Suggesting a series of smaller behavioural changes to facilitate a widespread, larger behavioural change is probably more effective than trying to institute drastic behavioural change. In the context of a weight loss application, this could mean suggesting smaller goals (such as minor calorie reduction) one at a time, rather than a list of larger goals that may be desirable but harder to achieve all at once.

e. 'Persuasive systems should always be open'

The system should not conceal that it is a persuasive technology, as this could reduce the effectiveness of the persuasive system or else be misleading. Working on the principle of voluntary behavioural change is important.

f. 'Persuasion should be unobtrusive'

The disturbance of a user when using the primary features of the technology should be minimised. Disturbing the user and preventing them using the technology can easily

demotivate them from using the technology and remove the user from reach of the persuasive system altogether.

g. Systems should be both useful and easy to use

This covers anything that serves the needs of the user, as a useless technology is not likely to be persuasive. However, the authors stress that this postulate is more of a necessity for all technologies than something specifically for persuasive technology.

Persuasion context

This section of the article analyses the process of convincing a user of technology to change their behaviours or attitudes, using empirical evidence on behavioural change from the field of psychology. The authors trace the path of persuasion from the persuader to the 'persuadee' (the user of the technology). The researchers check if the postulates are kept to through each step of the process. For example, as the technology isn't the persuader, the designer themselves must make it clear in the design process for the system they are creating that it is meant to be a persuasive technology in keeping with the fifth postulate.

The authors split the process into three stages

a. Intent

Identify whether the technology intends to change behaviour, attitudes or both. If the technology aims to change behaviour, acknowledging that permanent behavioural change will require more intensive persuasive technology. An mHealth app should aim to foster such permanent behaviour change.

b. The event

The actual act of persuasion will vary in effectiveness depending on the individual user and their receptiveness to direct and indirect methods, as outlined in the third postulate. To this end sensible placement and variety of direct and indirect methods in an mHealth app are recommended.

c. The strategy

The authors split persuasion into true persuasion, which relies on emotional and cognitive triggers to alter attitudes and behaviour, and 'convincing,' which relies more on

direct methods. Route selection (direct or indirect) depends on the user's individual receptiveness to cognitive cues or else receptiveness to logical argument, and so an effective persuasive system will likely tailor itself to an individual user

Design of system feature

The article provides a generic design process with an understanding of the principles coming before requirement definition.

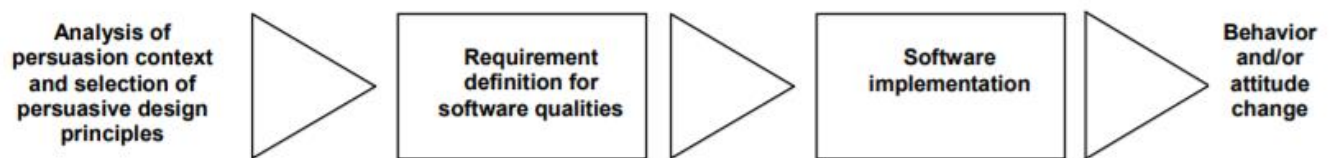


Figure 3. Generic Steps in Persuasive System Development

The article then presents the twenty eight principles for PSD organised in four categories:

Table 2. Primary Task Support

Principle	Example requirement	Example implementation
Reduction A system that reduces complex behavior into simple tasks helps users perform the target behavior, and it may increase the benefit/cost ratio of a behavior.	System should reduce effort that users expend with regard to performing their target behavior.	Mobile application for healthier eating habits lists proper food choices at fast food restaurants [Lee et al. 2006]. Smoking cessation Web site provides an interactive test that measures how much money a user will save with quitting.
Tunneling Using the system to guide users through a process or experience provides opportunities to persuade along the way.	System should guide users in the attitude change process by providing means for action that brings them closer to the target behavior.	Smoking cessation Web site offers information about treatment opportunities after a user has taken an interactive test about how addicted (s)he is on tobacco.
Tailoring Information provided by the system will be more persuasive if it is tailored to the potential needs, interests, personality, usage context, or other factors relevant to a user group.	System should provide tailored information for its user groups.	Personal trainer Web site provides different information content for different user groups, e.g. beginners and professionals. Web site for recovering alcoholics presents stories that are close to the user's own story.
Personalization A system that offers personalized content or services has a greater capability for persuasion.	System should offer personalized content and services for its users.	Arguments most likely to be relevant for the user presented first on a professional Web site rather than in random order.
Self-monitoring A system that keeps track of one's own performance or status supports the user in achieving goals.	System should provide means for users to track their performance or status.	Heart rate monitor presents a user's heart rate and the duration of the exercise. Mobile phone application presents daily step count [Consolvo et al. 2006].
Simulation Systems that provide simulations can persuade by enabling users to observe immediately the link between cause and effect.	System should provide means for observing the link between the cause and effect with regard to users' behavior.	Before-and-after pictures of people who have lost weight are presented on a Web site.
Rehearsal A system providing means with which to rehearse a behavior can enable people to change their attitudes or behavior in the real world.	System should provide means for rehearsing a target behavior.	A flying simulator to help flight pilots practice for severe weather conditions.

a. Primary Task Support

The principles that aid the user in the carrying out of their primary task with the technology, to make them want to keep using the technology and therefore leave them open to persuasion.

Being as these are closer to generic system design principles than PSD principles, they are all useful for the design of an mHealth app. Particularly useful for us are self monitoring and personalisation to enable a wide range of users with different goals to use the same mHealth app.

b. Dialogue Support

Table 3. Dialogue Support		
Principle	Example requirement	Example implementation
Praise By offering praise, a system can make users more open to persuasion.	System should use praise via words, images, symbols, or sounds as a way to provide user feedback information based on his/her behaviors.	Mobile application that aims at motivating teenagers to exercise praises user by sending automated text-messages for reaching individual goals. [Toscos et al. 2006]
Rewards Systems that reward target behaviors may have great persuasive powers.	System should provide virtual rewards for users in order to give credit for performing the target behavior.	Heart rate monitor gives users a virtual trophy if they follow their fitness program. Game rewards users by altering media items, such as sounds, background skin, or a user's avatar according to user's performance. [Sohn and Lee 2007]
Reminders If a system reminds users of their target behavior, the users will more likely achieve their goals.	System should remind users of their target behavior during the use of the system.	Caloric balance monitoring application sends text-messages to its users as daily reminders. [Lee et al. 2006]
Suggestion Systems offering fitting suggestions will have greater persuasive powers.	System should suggest that users carry out behaviors during the system use process.	Application for healthier eating habits suggests that children eat fruits instead of candy at snack time.
Similarity People are more readily persuaded through systems that remind them of themselves in some meaningful way.	System should imitate its users in some specific way.	Slang names are used in an application which aims at motivating teenagers to exercise. [Toscos et al. 2006]
Liking A system that is visually attractive for its users is likely to be more persuasive.	System should have a look and feel that appeals to its users.	Web site that aims at encouraging children to take care of their pets properly has pictures of cute animals.
Social role If a system adopts a social role, users will more likely use it for persuasive purposes.	System should adopt a social role.	E-health application has a virtual specialist to support communication between users and health specialists. [Silva et al. 2006]

The principles that allow the system to provide feedback to its users, through summaries and written/verbal information for the user. Worth keeping in mind for the design process of our app, as user feedback takes the system beyond a simple health monitoring app and allows it to provide specific user feedback. These principles also allow the app to motivate the user through the use of tone, which will in turn encourage the user to continue using the app and be exposed to the persuasive technology.

Praise important in the wording of notifications and feedback in response to user input. In addition, reminders to keep altering behaviour in line with user goals (e.g via notifications) are particularly useful in making our mobile application persuasive.

c. System Credibility Support

Users are more likely to trust an app, which has a certain degree of credibility, based on endorsement from other credible sources, links to sources considered credible or a nurtured reputation for its own credibility as a source. Therefore, the app's persuasion will be more successful.

Table 4. System Credibility Support		
Principle	Example requirement	Example implementation
Trustworthiness A system that is viewed as trustworthy will have increased powers of persuasion.	System should provide information that is truthful, fair and unbiased.	Company Web site provides information related to its products rather than simply providing biased advertising or marketing information.
Expertise A system that is viewed as incorporating expertise will have increased powers of persuasion.	System should provide information showing knowledge, experience, and competence.	Company Web site provides information about their core knowledge base. Mobile application is updated regularly and there are no dangling links or out-of-date information.
Surface credibility People make initial assessments of the system credibility based on a firsthand inspection.	System should have competent look and feel.	There are only a limited number of, and a logical reason for, ads on a Web site or mobile application.
Real-world feel A system that highlights people or organization behind its content or services will have more credibility.	System should provide information of the organization and/or actual people behind its content and services.	Company Web site provides possibilities to contact specific people through sending feedback or asking questions.
Authority A system that leverages roles of authority will have enhanced powers of persuasion.	System should refer to people in the role of authority.	Web site quotes an authority, such as a statement by government health office.
Third-party endorsements Third-party endorsements, especially from well-known and respected sources, boost perceptions on system credibility.	System should provide endorsements from respected sources.	E-shop shows a logo of a certificate that assures that they use secure connections. Web site refers to its reward for high usability.
Verifiability Credibility perceptions will be enhanced if a system makes it easy to verify the accuracy of site content via outside sources.	System should provide means to verify the accuracy of site content via outside sources.	Claims on a Web site are supported by offering links to other web sites.

When considering our idea for a product, the importance of expertise (by utilising empirical research in prototypes), surface credibility and verifiability (linking to outside sources on tailored advice, for example), as well as ‘real-world feel’ (information about individuals and an organisation behind an app) is high.

d. Social Support

Of particular interest are the principles around social support in the app, and how well social features can facilitate behavioural change.

Management of social cues, especially normative influence and social facilitation, to nurture sustained behavioural change is a powerful tool that could be utilised in our system. Social comparison is a principle that we need to approach with caution, as the potential for demotivation is clear in the context of an mHealth application, where users of all abilities and with varying goals can compare themselves to each other through a social feature.

‘Competition’ allows the incorporation of features that allow the user to compete with themselves (e.g the prize for quitting smoking for a month), which would help an mHealth app be inclusive for all types of users.

Table 5: Social support		
Principle	Example requirement	Example implementation
Social learning A person will be more motivated to perform a target behavior if (s)he can use a system to observe others performing the behavior.	System should provide means to observe other users who are performing their target behaviors and to see the outcomes of their behavior.	A shared fitness journal in a mobile application for encouraging physical activity [Consolvo et al. 2006].
Social comparison System users will have a greater motivation to perform the target behavior if they can compare their performance with the performance of others.	System should provide means for comparing performance with the performance of other users.	Users can share and compare information related to their physical health and smoking behavior via instant messaging application [Sohn and Lee 2007].
Normative influence A system can leverage normative influence or peer pressure to increase the likelihood that a person will adopt a target behavior.	System should provide means for gathering together people who have the same goal and make them feel norms.	A smoking cessation application shows pictures of newborn babies with serious health problems due to the mother's smoking habit.
Social facilitation System users are more likely to perform target behavior if they discern via the system that others are performing the behavior along with them.	System should provide means for discerning other users who are performing the behavior.	Users of a computer-based learning environment can recognize how many co-students are doing their assigned homework at the same time as them.
Cooperation A system can motivate users to adopt a target attitude or behavior by leveraging human beings' natural drive to co-operate.	System should provide means for co-operation.	The behavioral patterns of overweight patients are studied through a mobile application, which collects data and sends it to a central server where it can be analyzed at the group level in more detail [Lee et al. 2006].
Competition A system can motivate users to adopt a target attitude or behavior by leveraging human beings' natural drive to compete.	System should provide means for competing with other users.	Online competition, such as Quit and Win (stop smoking for a month and win a prize).
Recognition By offering public recognition for an individual or group, a system can increase the likelihood that a person/group will adopt a target behavior.	System should provide public recognition for users who perform their target behavior.	Names of awarded people, such as "stopper of the month," are published on a Web site. Personal stories of the people who have succeeded in their goal behavior are published on a smoking cessation Web site.

Conclusions

- The seven postulates of PSD, which prototypes should fulfil in order to properly nurture new behaviours and attitude change in users.
- Dialogue support to offer personalised feedback to users in order to maximise the persuasiveness of the app to each individual user is advisable.
- Ensuring features are based on empirical research or reliable outside sources and communicating this to users.
- The inclusion of an in-app social network has the potential to significantly enhance persuasive technologies.

- The inclusion of challenges, both against other users and solo challenges, can utilise a natural desire to compete in order to facilitate behavioural and eventually attitude change.

2.1.3. Long term engagement with mHealth mobile applications

Review of: Vaghefi, Isaac. and Tulu, Bengisu. 2019. The Continued Use of Mobile Health Apps: Insights From a Longitudinal Study. *JMIR mHealth and uHealth*, 7(8), p.e12983.

The Continued Use of Mobile Health Apps: Insights From a Longitudinal Study (Vaghefi and Tulu, 2019) examines how users of mHealth applications (mobile applications that focus on changing user's unhealthy behaviour) engage with such systems and what influences whether they engage with them in the long term. The study identifies the key factors that influence the user's decisions and provides detailed recommendations on how to increase user engagement with an mHealth application.

Study Overview

The aim of the study is to understand how users engage with mHealth mobile applications, focusing on what encourages (or discourages) them from continuous engagement and commitment to the changes they want to implement in their life. The assessment of different features is focused on the user's experience and perceptions of an mHealth application of their choice, which they were encouraged to use as part of this study. The researchers analysed both the capabilities of the system (defined as 'user experience') and the goals and personal 'intent' of the user when considering the factors that contribute to long-term engagement.

Key features

The study highlights some of the key features users struggled with or found beneficial when using mHealth mobile applications. The key factors that influence user behaviour presented in the study are as follows:

a. Interface Design and Navigation

Users indicated a clear preference for minimalistic design, where key information/features are highlighted. The participants indicated that being presented with too much information can be confusing and make navigating around the app harder to manage. Clear preference for '*smooth flow* between screens' and an accessible 'easy-to-understand' navigation menu.

b. Data collection

Collecting information about the user's input (when behaviour is repeated over time) is shown as beneficial for the efficiency of the system, as the participants found inputting information easier when they were presented with suggestions. The users indicated data collection as 'convenient.'

c. Depth of knowledge

Participants indicated that having a 'sufficient' amount of freely available information that they believe to be reliable is likely to increase their engagement with the respective mHealth application.

d. User control over the system

On the whole, the participants in this study expected to have control over goal management. However, the degree to which control was expected when setting goals varied across individuals. Additionally, users indicated that a disadvantage of the mHealth applications they were using was a lack of flexibility. The participants stated they would like to have more control over the way(s) in which their progress is being measured, as opposed to being restricted to a particular method(s).

In terms of the frequency of notification, user's preference varied across the board. However, the ability to control the amount and type of notifications they receive was perceived as 'motivating.'

e. Actionable Recommendations

The study found that users of mHealth applications were pleased when the app provided them with progress updates, recommendations based on previous input, 'personalised data analysis' and goal projections. These attributes of the software (when present and sufficient for the user's needs) are likely to encourage long-term engagement.

Additional notes:

Participants in this study expressed a preference for mHealth apps that utilise a tutorial-type introduction to the application (here called 'wizard'). As indicated by the users, this feature allows them to familiarise themselves with the main functionalities of the software early on and makes the experience more positive. Users also indicated that understanding the 'system rules' of the software is important for their long-term engagement.

Problems of the study:

As identified by the researchers themselves the scope of the study has been quite limited, due to the limited number of participants.

The study identifies some subjective factors (e.g amount and type of received notification, the time a user can dedicate to a mHealth app) that will inevitably vary in different user groups. Additionally, the information provided by the users can sometimes be ambiguous ('sufficient' amount of information that the user 'perceives as reliable', 'easy-to-understand' design). As the study indicates, the fit between the user and the system is vital when it comes to those factors.

Although the factors of long-term engagement of users with mHealth applications identified by the researchers could be helpful in developing, testing or evaluating software, it is important to note that the study also recognises that the continued use of mHealth applications is dependent on the user's personal motivation, persistence and intent. The engagement of the users can only be increased to a limited extent, as factors from outside of the application will always be important regarding changes of behaviour.

2.1.4. Strategies for weight loss

Review of: Pagoto, Sherry., Schneider, Kristin., Jojic, Mirjana., DeBiasse, Michele. and Mann, Devin. 2013. Evidence-Based Strategies in Weight-Loss Mobile Apps. *American Journal of Preventive Medicine*, 45(5), pp.576-582.

The last piece of literature focuses on behavioural change in relation to weight loss. 'Evidence-Based Strategies in Weight-Loss Mobile Apps' (Pagota, Schneider et al, 2013)

examines the most downloaded mHealth applications marketed as weight-loss applications and identifies how many of the evidence-based behavioural strategies from an in-person lifestyle intervention programme each one utilises.

Study overview

This study is an investigation into how many of the twenty behavioural strategies used in the Diabetes Prevention Programme, an evidence-based medical weight-loss intervention, are utilised by the top weight-management applications available on Apple's App Store and on Android's Google Play. Such techniques 'have been shown to be effective for weight-loss and reduction of risk for cardiovascular disease and diabetes.' (Look Ahead Research Group, 2007) This suggests that the use of such strategies could not only aid in weight loss, but help sustain a healthy lifestyle in the long run. The study argues that if these behavioural strategies were properly utilised they could be useful tools with the potential to serve as resources for physicians to encourage lifestyle change.

The study looks not just at how commonly implemented these evidence-based behavioural strategies are, but also how they are used in conjunction with the technology available when delivered as a mobile application. The study seeks both to find out how common behavioural strategies are in mHealth apps and also how well behavioural strategies are translated for use in applications, and therefore, how well mHealth applications capitalise on their 'potential to be a helpful tool.'

Aims

The study summarizes its aims in 4 categories:

- 'identifying the commercial weight-loss mobile phone apps that include the highest proportion of behavioural strategies represented in evidence-based life-style interventions'

This will be of particular interest in conjunction with the app reviews for this project, as the conclusions of the study in terms of how many of the strategies particular apps

integrate can be compared and contrasted with the conclusions that are made in the reviews of those apps. This can be used to draw separate conclusions as to the usefulness of including more and more of these behavioural strategies in an application.

- ‘identify which behavioural strategies have yet to be adapted into a mobile phone app format’

This will potentially yield results with direct applications in the prototyping stage of this project, in line with our goals defined in the project definition (i.e creating sustainable healthy habits), which require behavioural change strategies to be delivered via our application.

- ‘identify technology-enhanced features of apps that reduce user burden or provide in-the-moment intervention

This has direct mHealth HCI applications, and so the conclusions of this will potentially be relied upon heavily in prototypes, particularly the ways in which applications in this study substitute technology for the personal elements in the Diabetes Prevention Programme and how these methods can be integrated into prototypes, to promote behavioural change and therefore achieve sustained healthy lifestyle habits.

- ‘compare free to paid apps in terms of evidence-based strategies and technology-enhanced features’

This isn’t highly relevant to the project, however it could be of some use to know if there are features in ‘paid’ apps that can be integrated into prototypes.

Methodology

The study selected for review the top 100 paid and top 100 free mHealth apps from the Apple Store and from the Google Play Store. It sorted by downloads from applications in the ‘health and fitness’ categories on the app stores. There was a screening process based on the descriptions of the applications. Only applications that self-identified as weight-loss aids

were included; if an app described itself as a diabetes management application, for example, it would be excluded regardless of inclusion of weight loss tracking features.

The study also only included applications that included diet and exercise self-monitoring, as these are such empirically validated and ubiquitous features in weight loss and weight management (Burke, Wang et al, 2011) that applications that did not include them were not worth considering.

The assessment criteria for these applications was derived from the 20 evidence-based behavioural strategies for weight loss found in the Diabetes Prevention Programme lifestyle intervention (Look Ahead Research Group, 2007) which the study calls a 'landmark' which had been subject to 'numerous efficacy and effectiveness studies'. Each app was reviewed independently by 2 assessors who would come to an agreement as to which of the strategies the app adopted, and the results would then be formalised in the database. The data is presented as a list of the 20 strategies with a percentage of the reviewed apps that adopted it.

Analysis and Conclusions

Table 1. Evidence-based behavioral weight-loss strategies represented in weight-loss mobile apps

Strategy	DPP session title ^a	Description	% apps
Weight-loss goal	Welcome to the Lifestyle Balance Program	Participants are given a goal of 7%, or 1–2 pounds per week.	93.3
Dietary goal	Getting Started Losing Weight	Participants are given a fat and/or calorie goal that is consistent with weight-loss goal.	90
Calorie balance	Tip the Calorie Balance	Participants learn how healthy eating and being active are related.	86.7
Physical activity goal	Getting Started Being Active	Participants are encouraged to get 150 minutes of moderate-intensity physical activity per week.	20
Exercise safety	Being Active a Way of Life/ Jump Start Your Activity Plan	Participants are instructed on how to measure exertion and avoid injury.	20
Benefits of healthy diet and physical activity	Welcome to the Lifestyle Balance Program	Participants learn of the health benefits of making lifestyle changes.	13.3
Food substitutions	Be a Fat Detective	Participants learn healthy substitutions for foods that are high in fat and calories.	10
Food pyramid	Healthy Eating	Review current food pyramid and its recommendations.	6.7
Stimulus control	Taking Charge of What's Around You	Participants learn about food and activity cues and ways to change them.	6.7
Portion control	Be a Fat Detective	Participants learn to use scales, measuring cups, and spoons.	6.7
Lifestyle activity	Being Active a Way of Life	Participants are encouraged to engage in lifestyle activities (e.g., parking further away).	6.7
Target heart rate	Jump Start Your Activity Plan	Participants are instructed on how to measure their target heart rate.	6.7
Problem solving	Problem Solving	Participants learn a five-step process to brainstorm new solutions to problems that inhibit their progress.	3.3
Stress reduction	You Can Manage Stress	Participants learn how to prevent stress and cope with unavoidable stress.	0
Relapse prevention	Slippery Slope of Lifestyle Change	Participants learn to identify what causes slips from healthy eating and being active and how to recover from them.	0
Negative thinking	Talk Back to Negative Thoughts	Participants learn how to identify negative thoughts and talk back to them with positive ones.	0
Social cues	Make Social Cues Work for You	Participants learn how to identify problem social cues and add helpful ones.	0
Develop regular pattern of eating	Healthy Eating	Participants are instructed to eat three meals.	0
Time management	Being Active: A Way of Life	Participants learn strategies for fitting exercise into their schedules.	0
Nutrition label reading	Be a Fat Detective	Participants learn to read nutrition labels.	0

^aThe DPP Lifestyle Intervention Protocol can be found at www.bsc.gwu.edu/dpp/lifestyle/dpp_part.html.
DPP, Diabetes Prevention Program.

- ‘identifying the commercial weight-loss mobile phone apps that include the highest proportion of behavioural strategies represented in evidence-based life-style interventions’

Existing applications do not include a majority of the twenty evidence-based behavioural strategies for effective weight loss outlined in the Diabetes Prevention Programme. The app with the highest use of evidence based strategies was MyNetDairy and its ‘pro’ version. MyNetDairy achieved this largely through a ‘library,’ which provided advice that is a crucial element of many of the behavioural strategies identified in the DPP. While other apps linked to off-app sources, MyNetDairy integrated information into the app.

- ‘identify which behavioural strategies have yet to be adapted into a mobile phone app format’

Seven crucial behavioural weight loss strategies not included in any top applications on the market:

- Stress tracking is rare, but actual advice on stress management is absent from all top applications.
 - No provisions for dealing with negative thoughts.
 - No application includes advice on how to stop themselves slipping from healthy eating and exercise habits, which is crucial for the sustained lifestyle changes we outlined in our project.
 - No help in dealing with social cues or replacing negative social cues with positive ones.
 - No top application actively encourages regular meal patterns (i.e eat 3 meals a day).
 - No top application helps the user with time management or advises the user on how to fit exercise into a busy schedule.
 - No top application offers help regarding reading nutritional information labels.
-
- ‘identify technology-enhanced features of apps that reduce user burden (e.g., barcode scanners) or provide in-the-moment intervention (e.g., automatic reminders to record food intake)’
 - Most common technological integration in top apps is barcode scanning for recording food consumption.
 - ‘46.7% included a social media component, involving the capability to either connect to other app users or post to an online social network, such as Facebook, Twitter, or one created by the company itself.’
 - Very few included a calendar for the purpose of scheduling exercise.
 - Very few allowed the user to record notes about stress, feelings and thoughts, though none of these offered content on fighting negativity in these areas.
 - Merely 3% of top apps included automatic exercise tracking.
 - Social networks are an important source of social support, which is present in the in-person DPP, but absent in many of the reviewed applications.

- Only 20% of apps sent reminders to users if they forgot to track food or exercise intake and only 10% of apps sent reminders to users before mealtimes to encourage a regular eating pattern.
- ‘compare free to paid apps in terms of evidence-based strategies and technology-enhanced features’

There was no real difference between paid and free apps in occurrence of evidence based weight loss strategies. Therefore, a subscription service/one off payment is not an indication of effectiveness.

Limitations:

Ranking applications by uptake of the twenty behavioural strategies for weight loss identified by the study is flawed as an analytical device. By the study’s own admission ‘whether all of these behavioural strategies are necessary to the efficacy of a lifestyle intervention is unknown.’ To this end, we cannot say whether including **more** of the strategies necessarily makes an app more effective in nurturing sustained weight loss and to an even greater extent whether or not it helps nurture sustained lifestyle change.

2.1.5. Conclusions from the cited literature:

Users prefer easy to navigate, minimalist interface design. It encourages sustained use of an mHealth app and facilitates behavioural change for longer, therefore encouraging sustained healthy lifestyle habits to form. Additionally, ‘*The Continued Use of Mobile Health Apps: Insights From a Longitudinal Study*’ suggest that users find it helpful to receive guidance regarding the navigation of the application, which increases the long term engagement by flattening the initial learning curve.

Providing the user with information that is perceived as trustworthy encourages sustained use of an application and therefore, aids in forming long-term healthy lifestyle habits. The provided information also enables the user to make informed healthy lifestyle

choices. Informing the user and fostering trust in this information is clearly important to enabling behavioural change in users.

Sending notifications to users to remind them to track their intake and encourage them to document their progress results in increase in motivation to use the app, thereby lowering the increasing the likeliness of a change in behaviour. While notifications are important for nurturing behavioural change in mHealth applications, however emphasises that tailoring notification frequency to an individual user's preferences helps maximise the long term use of mHealth apps.

Including an element of social interaction is highly beneficial in fostering behavioural change of the kind our project definition requires. Many of the least-replicated 20 DPP strategies found in mHealth apps were the socially-oriented strategies of the programme. However, only 3% of top mHealth apps have a social network feature, which has been identified as a pitfall for many existing applications.

2.2. Review of existing mobile applications

Based on our research and personal experiences with mHealth/Weight Management mobile applications we have decided to evaluate a selection of popular mHealth applications in regards to how they implement the features discussed in the literature such as providing information that can be perceived as reliable, ease-of-use, notifications and design. We have identified the following categories as the most important:

- I. Recommendations and guidance
- II. Interface – Navigation, data collection (for convenience), visual aids
- III. Notifications
- IV. Goal management (and options)
- V. Personal progress analysis
- VI. Other enhancing features

2.2.1. Weight Watchers

The Weight Watchers franchise has been one of the leading figures in the weight loss industry since the 1960's. Their programmes are built around the weight watchers point based dietary system, which avoid a focus on calorie intake, instead scoring meals on their nutrient and energy density levels. Their points scale indicates both the quality of the meals and the quantity limit, therefore lean, low fat meals can be eaten in larger quantities and on a more regular basis. Moving to an app-based system is logical for the weight watchers programme. The programme benefits from the immediacy of phones-based technology and access to professional advice at any time of day.

As well as specific diets, the programme traditionally involves several strategies to help people adjust their eating behaviours. A combination of counseling via weekly or monthly group meetings, calorie targets, online support and encouragement to take up regular exercise all play key roles in the long term success of the weight watchers programme.

Whether originally conscious or not, the combination of the support from professionals combined with other members on the programme strongly support several principles of behavioural change. A quick comparison between the methods used by weight watchers and the methods discussed in the first study show many correlations. Goals, monitoring, feedback, comparison, social comparison, goal review, habit formation and prompt are just some of the behavioural methods that can be tied into the methods used by weight watchers. Arguably, the success of the weight watchers programme could be strongly tied to its strong connections with behavioural psychology.

The following paragraphs focus more specifically on the app side of the weight watchers programme.

I. Recommendations and guidance

The app has several features which aid the user in following their programme and make a wealth of information available to them very easily, helping the user to track their progress. Weight watchers create their own meals in order to balance these points scales and a

subscription to their programme gives you a plan and recommendations about which meals to purchase from them.

II. Interface

Point based systems for food and fitness provide focussed incentives and goal based progress making the app more rewarding and providing daily satisfaction, motivation and breaking overall goals into manageable targets

The app has no free to use features, a subscription based system is required to access the app which limits the consumer base to those who can afford the monthly subscription.

The app has a limited fitness section, as the focus is primarily influencing the user's food intake.

III. Notifications

The app pushes the user to purchasing more Weight Watchers products.

IV. Goal management (and options)

The app features weight loss graphs for the user to easily monitor their improvement in a visual way.

The app has a reward points system to encourage the user to stick to their plans and a large active community allowing users to connect, encourage and support with each other.

V. Personal progress analysis

The application offers weekly private wellness check-ins, in addition to the previously mentioned advice and guidance from a weight loss coaches. Users can also receive wellness check-ups from any location opening the programme up to anyone with a network service.

The featured programmes, labeled as 'tailored' can be limited and can often be more built around more general advice rather than truly personal.

VI. Other enhancing features

- Barcode scanners for users to easily input their consumption
- Recipe books with detailed nutritional information are available digitally to provide inspiration and recommendations
- Basic fitness monitoring, such as step count and active minutes

- The community section allows for users to share experiences and offer each other support and encouragement

2.2.2. MyFitnessPal

MyFitnessPal is one of the leading weight management applications currently on the market. The application is popular with a variety of people as it offers users a large database containing various food items and recipes from all over the world, can connect to various external devices, has a clean and aesthetically pleasing interface and provides additional recommendations for the user whenever they input a food item or complete an exercise activity. The application is also innovative in the way it records progress with the ‘If everyday was like today..’ feature, which is beloved by users.

Unlike other apps, MyFitnessPal does not allow for a user to access this feature if their daily caloric intake is less than 1000 calories. When inputting goals, the app warns the user in regards to unhealthy expectations (goal weight below the recommended range), however it does allow the user to still input an underweight option as a goal. It also allows for a user to input a daily calorie goal under 1000 calories/day, despite considering this unhealthy when ‘completing’ a diary entry.

The application has a dashboard, a diary and a personal tab. The dashboard contains content from ‘friends’ and advertisements. The diary contains a daily summary of all food, exercise and water a user has logged. The personal tab shows the user’s progress, their profile, wall and friends’ list and provides access to the settings.

I. Recommendations and guidance

The application provides details about the different components of the foods that have been added to the database, including macro- and other nutrients. However, the amount of information provided varies significantly among the different food items and, as users have the option to add items to the database, the information available might not always be coming from a reliable source.

When a user adds a food or a meal to their food diary, the app offers colour-coded comments [green = behaviour that is to be encouraged; red = behaviour that is to be discouraged] (e.g. ‘This food is low in saturated fat.’, ‘This food has a lot of calcium.’, ‘This food is high in fibre.’) as well as suggestions based on the daily nutritional goals (e.g. ‘Your daily goal is to eat less than 40 grams of fat.’, ‘Your daily goal is to eat less than 150 grams of carbohydrates.’). This can be useful to educate the user about the different food choices they make and help them better understand nutrition. In the long term, this can help them make healthier choices.

When a user has logged all of their food intake and exercise for the day, they have the option to ‘Complete’ their day and see a report on their behaviour. This comes in the form of a feature known as the ‘If every day was like today..’ feature. MyFitnessPal provides the user with an estimation of their weight loss/gain in 5 weeks based on the food and exercise they have logged that day. Once a user has completed a day their ‘streak’(found in their social profile) will also increase. MyFitnessPal does not provide a projection for the finishing date.

II. Interface

MyFitnessPal provides the user with a daily breakdown of when most calories were consumed (per meal), detailed information about the nutrients the user is consuming** and a pie chart breakdown of the macronutrients for the day, as well as a comparison to the daily nutritional goals of the user.

The application collects data of the users’ input, which makes the diary entries less time-consuming when using the app for longer periods of time (presuming they occasionally consume the same food items), which has been observed to be helpful for users. (Vaghefi, Tulu 2019)

In a study commenting on the usability of an older version of MyFitnessPal users identified several problems with the interface. (De Francisco, Freijser et al) The biggest issue was the overwhelming amount of information and food item choices the users had to navigate through. The study identified significant differences between the amount of calories as recorded by the different participants, which consumed the same meal. It also highlighted users’ challenges in finding a particular food item, recalling information about the consumed food and guessing portion sizes.

****The values are based on the values in the database. If a food item does not have information about a certain nutrient, the daily amount of that nutrient remains unchanged, which can be misleading.**

III. Notifications

The app has default meal reminders, but it allows the user to adjust the times and/or the frequency of reminders. MyFitnessPal has a weekly weight-in reminder that can be adjusted or switched off. Additionally, the app has a lot of reminders connected to the social features, such as 'new message', 'new friend request', etc. The number and type of reminders can be adjusted. The amount of notifications can depend on how actively the app is used, however the option to adjust them makes MyFitnessPal suitable for different types of users.

IV. Goal management (and options)

Although the app focuses on weight, it allows the user to track their progress through neck, hips and waist measurements. It also allows the user to adjust their daily food goals (e.g. calories consumed, macronutrients percentages, other nutrients) as well as the amount of exercise they would like to do in a week (in minutes or in times per week). By offering both recommended values and allowing the user to control their goals, the application caters to both people who are knowledgeable about dieting and want to follow a particular plan and complete beginners. The 'premium' version of the app also contains options for a 'Macronutrient Focus', 'Heart Healthy', 'Low Carb' or 'Custom' diet plans to allow for an approach less focused on calories.

V. Personal progress analysis

The application offers multiple different graphic representations of the amount of weight lost/gained by the user so far and how far they are from their goals. Visualisation of the process is a useful tool to encourage weight loss/gain.

VI. Other enhancing features

- Tracking water intake
- Connecting to a variety of pedometers and exercise trackers
- Allows the user to write additional notes in regards to their food intake and exercise

- Community: MyFitnessPal has a variety of social features (e.g dashboard, friends list, wall posts, messaging system). This creates a sense of community and can be useful for keeping people on track

2.2.3. NHS Weight Loss App

The NHS Weight Loss Plan app provides users with a 12-week weight loss programme. It keeps track of weekly weight change, calorie intake and waist size change. The focus is on healthy habits rather than a specific weight loss goal or a caloric intake target. The app also has a feature for the recording aerobic exercise and strength training. However, it does not calculate their effect as a caloric deficit.

I. Recommendations and guidance

The app offers off-app resources (primarily from the NHS website) for planning meals, calorie counting and information about BMI. Being produced by the NHS, those resources are based on credible medical advice.

The calorie deficit calculator uses an assumed required intake based on gender and regardless of factors like height or weight, which makes the advice provided by the app very general.

II. Interface

The design, although simplistic, is hard to navigate. Each week of the programme has a large 'Week 1' box, which links to healthy eating advice and case studies of people who have used the programme and a much smaller box underneath where the user actually accesses the weight loss charts and exercise tracking features.

The calorie deficit calculator relies on the user to know the exact number of calories they consume in a meal and to input this themselves.

The app relies primarily on off-app resources and has very few fully fleshed out features of its own.

III. Notifications

There are no notifications of any kind, so a user isn't reminded to input weight daily or calorie intake at regular intervals (i.e after meals).

IV. Goal management (and options)

Another major feature of the app is the ability to chart how many of their 5-a-day of fruit and vegetables a user consumes through a simple tick box that does not allow the user to input the specific food they've consumed.

The programme is only limited to 12 weeks.

V. Personal progress analysis

As the mobile application's focus is healthy lifestyle, as opposed to weight loss, the user cannot set a specific weight loss target. Instead, the app recommends calorie intake and asks you to chart your weight to track your personal progress..

VI. Other enhancing features

The 5-a-day tracker reminds the user to inject a variety of healthy foods into their diet rather than focusing purely on calorie intake. However, it does not allow you to specify the variety of fruit and vegetables you consume, nor does it allow you to exceed 5 portions per day.

2.2.4. Endomondo

Endomondo is a fitness tracking app with a focus on jogging, running and cycling. It features route trackers, which allow for users to track distance.

I. Recommendations and guidance

Features training plans and recommendations useful for beginners.

II. Interface

Easy to use, clean design. The app automatically calculates how many calories the user burned, based on the distance and the average pace the user. However, workouts that cannot be tracked by GPS leaves room for user error.

III. Notifications

Notifies you when you haven't met your challenge for the week

IV. Goal management (and options)

Setting challenges and goals motivates people to try and meet those goals and to report back to the app

Social features and social network integration allow for sharing when those goals are met and comparison with other users - could increase the number of people using the app as they see it on their social media or users convince friends to join so they can compare each other's progress

V. Personal progress analysis

The app includes daily reviews of distance and top speed of runs and allows for comparison of pace during different stages of the run and over different days. It also offers training plans and recommendations on how the user can improve their performance.

There are also weekly goals and challenges, which aim to motivate people to exercise.

Social features allow for people to check their progress against their friends and family, and it is integrated with social networking sites such as Facebook and Instagram.

VI. Other enhancing features

- Can connect with Fitbit and similar devices, in order to better track exercise by checking heart rate or cycling speed. It can also connect with MyFitnessPal to access nutritional information.
- Route tracker

2.2.5. LifeSum

Lifesum is a mobile application for monitoring food intake and exercise. It includes a variety of recommendations for eating plans and recipes. LifeSum focuses on having all the features for sustainable weight loss all in one convenient place. The app caters to different diets such as keto, low carbohydrates and high protein. The user can select what type of diet they want from the 'plans' page of the app, which include 'balanced diets', 'fasting diets', 'Scandinavian' and 'Mediterranean' diets.

I. Awareness of healthy eating habits

The app gives a detailed breakdown of calories left per day as well as how much fat, protein and carbohydrates you have consumed. Depending on the diet, the app also gives a score for the users eating habits that week.

No warnings for, monitoring of or safety features against overeating and undereating, could leave users at risk of eating disorders

II. Recommendations and guidance

The app encourages regular eating patterns at breakfast, lunch and dinner, as well as set macros for the user and recipes.

LifeSum also asks the user about their eating habits when they use it for the first time. This allows for the app to better understand the users food intake, and provide recommendations.

III. Interface

Clear, easy-to-use UI with interactive inputs.

Suggested recipes, which give the user more of an incentive to follow recipes and stick to healthy options suggested.

The user can search for the nutritional information of most kinds of foods from a central database.

IV. Notifications

V. Goal management (and options)

LifeSum divides the user's caloric intake depending on the number of meals they have a day and shows trends in calorie intake across days.

VI. Personal progress analysis

The app gives the user a score of their eating habits based on current food consumption.

Progress is shown through visual aids such as graphs.

VII. Other enhancing features

- Barcode scanner
- Can connect to pedometers and exercise trackers

- Exercise tracking

3. User-based personas and scenarios

3.1. Persona 1

- **Profile**



Name: Harvey Britton

Age: 25

Occupation: General administrator

Income: Steady salary

- **Main points:**

- Fairly active when younger
- Has never had to worry about weight before
- Still comfortably within the healthy weight range
- Has been concerned that they are doing much less exercise than in the past
- Likes to snack on slightly less healthy food items
- Has some old equipment such as a bike

- **Goals:**

- Wants to maintain a healthy weight
- Wants to get back into more regular gentle exercise
- Wants to be more aware of what they eat
- Wants to build up a healthy lifestyle regime and is interested in long term lifestyle changes
- Interested in receiving dietary suggestions from time to time

- **Frustrations:**

- Does not want to invest a lot of time into inputting information

- Wants motivation to build exercise habits without having to worry about his pace or distance
- Does not like being overwhelmed with notifications
- Does not want to drastically change their diet
- Finds it hard to balance his work, social life and exercise routine

○ **Description:**

Harvey has graduated university five years ago. He is working as a general administrator. As a boy he competed in tennis, training for 5 hours a week. At university he used to run on Wednesday afternoons and play casual tennis twice a week with friends. However, working full-time and leaving university has impacted his lifestyle and he has developed some unhealthy habits. Since graduating stopped his weekly running sessions and no longer lives near the friends he played tennis with. The lack of exercise has had an effect on his energy levels and Harvey has grown concerned that his desk job will cause him to slip into poor habits.

Although, in the past he was able to eat most things without worrying, Harvey understands that this may not last forever. Importantly however, he does not wish to alter his diet hugely as he is looking to introduce long-term healthy habits into his life. He would rather be able to lightly monitor what he is eating on a regular basis to make more informed decisions on his food choices.

Harvey is still in the healthy weight range and only wants to maintain his current weight. His priority is developing active lifestyle around his day job, to allow him to stay healthy indefinitely.

Scenarios:

1. It's a Thursday evening and Harvey has just finished work for the day. He heads home via Starbucks and picks up a muffin with a coffee. He watches some average TV for a while, cooks a pie with mash, carrots and green beans for dinner and watches a bit more TV before heading to bed. In bed, he realises that he had enough time after work

to go for a quick bike ride or run before having his dinner. The muffin he ate could have been slightly offset by this small bit of exercise and it would make him feel a little better about his overall health. He wishes that he had thought about a bit of exercise after work rather than watching TV but he is out of an exercise routine.

2. It's a Sunday morning and Harvey is feeling tired. He caught up with general chores the day before and went out to the pub with some old friends. He decides to lie in until 11:30. He has a fry up for lunch and sits down to watch the rugby on the sofa. Whilst watching he snacks a bit on a bag of crisps and a slice of cake. After the rugby he decides to go for a very quick walk before preparing a roast dinner and heading to bed. Most Sundays are similar, and this becomes a fairly regular eating habits

3.2. Persona 2

○ Profile



Name: Ellen Thomson

Age: 35

Occupation: Retail assistant

Income: Working-class salary

○ Main points

- Has been conscious of her weight for a long time
- Has experience with different diets with varying levels of success
- Married and a mother of two children
- Gained weight during her second pregnancy.
- Her second child has recently started going to school, so she is considering dieting as she will have more free time.
- Enjoys socialising with others, eating out and spending time outdoors with her children
- Both she and her partner cook in the household.

○ Goals

- Ellen's main aim is to lose weight to improve her health and confidence. She has no timeframe in mind.
- Prefers a plan that's easy to follow and doesn't require her to buy expensive food or invest a lot of time.
- She's interested in something flexible she can apply to her life, but is willing to try new things.

- **Frustrations**

- Rarely gets the opportunity to exercise, because of her busy schedule
- Has previous negative experience with dieting and weight loss groups, which makes her think of dieting in the context of all or nothing
- When she cooks, Ellen often chooses food her children and/or husband like and doesn't know much about 'healthy alternatives'

- **Description**

Ellen has grown up conscious of her weight. Although as a teen, she maintained a healthy weight, Ellen has always enjoyed food. Because of her self-consciousness about her body Ellen did not participate in group sports in school or university and instead focused on her other hobbies, such as interior design, cooking and travelling. Ellen is really outgoing and enjoys spending time with her family and friends. During her early 20s even started slipping into bad habits and after getting married and experiencing two pregnancies, she has gotten progressively heavier and is now in the overweight range.

Now that her youngest has started going to school, she has decided to try to improve her health and wellbeing by introducing small changes into her lifestyle. However, Ellen has tried multiple diets in her twenties, but none of them have provided her with long term solutions. Because she is aware of trends and enjoys socialising, Ellen has previously followed popular fad and crash diets and now associates dieting with negative emotions of extensive limitation. For her it is important to receive suggestions that work with her existing schedule and adapt to her needs.

Ellen enjoys cooking, as well as tasting her mother and her partner's food. Family dinners, inviting friends over for a meal and trying out various recipes are part of Ellen's everyday life. While she is interested in losing weight, she is also very aware that resisting her mother's homemade food on a Saturday night is near impossible.

Scenarios

1. It's Saturday evening and Ellen and her family are visiting her parents for their weekly evening meal. The dinner is an event for both families, as the grandparents enjoy seeing the kids and catching up with their daughter. Ellen has a strong relationship with her mother and loves her food. Her mother insists that everyone tries the food and always encourages Ellen to eat more. This is the highlight of Ellen's week as she can enjoy playing with her kids, eating her mother's homemade food and sometimes even manages to catch up with her sister that visits occasionally. Ellen often does not keep of what she eats, while enjoying her family time.
2. It's her partner's time to cook. Although Ellen has been trying to 'watch what she eats,' they surprise her with her favourite meal – a lasagne. Ellen is touched by the gesture and cannot bring herself to refuse her partner's offer as she agrees to eat a small portion of the dish. Later than evening, Ellen is still craving her favourite meal and happily has another portion for dinner.
3. It's Monday morning and Ellen has to prepare lunch for her children. Last night she planned on cooking separately for herself and her children, but she didn't have a good night sleep and woke up too late. She no longer has the time to prepare two sets of lunch. Ellen chooses to double the portion of mac and cheese that she's cooking for her children and have that for lunch as it is easier to cook. Ellen feels guilty for not waking up on time and her mood affects her entire day.

3.3. Persona 3

- **Profile**



Name: Ben Davies

Age: 21 years old

Occupation: University student

Income: Primarily student loans

- **Main points:**

- Enjoys going to the gym
- Would like to gain more muscle weight
- Likes to get feedback and share his progress with friends
- Is conscious of maintaining a healthy lifestyle

- **Goals:**

- Wants to receive recommendations on what kind of food to eat
- Is interested in receiving guidance in their exercise routine
- Wants to be able to share his progress with his friends

- **Frustrations:**

- His budget is a limiting factor in what Ben can afford to experiment with food-wise
- Wants to increase his performance as a rugby player

Descriptions:

Ben is a student in his third year at university and wants to maintain a healthy lifestyle. In particular, Ben wishes to work on his muscle strength. He also wants to gain weight as he believes that will help him to perform better on his sports team at university. He is extremely self-conscious about himself and wants to continuously be able to update his friends about his progress at the gym. He is interested in engaging with fitness related pages and shares a lot of information about his workouts online.

Ben has previously used different mobile applications to monitor his workout and food intake. However, he struggles to remember to input his food intake and often finds the recommended meals are out of his budget.

Scenarios:

1. Often Ben struggles to find enough time to do long workout sessions as a full-time university student. He often opts for a quick 30-minutes workout. However, upon walking into the gym on a Monday afternoon, he finds that all the equipment he was interested in using is currently not available. Ben only has half an hour to complete his workout and unfortunately, is unable to perform all the exercises he wanted. He leaves the gym frustrated rather than energised from his gym session.
2. Ben has gone for his weekly shop in a local grocery store. He is interested in cooking a new recipe, but all the suggestions he can find online after searching 'healthy food' come up with expensive recipes he cannot afford or difficult and time-consuming dishes. Ben is disappointed and unwillingly buys the same groceries he always does, without taking into account any of the nutritional labels. He focuses on getting things that are cheap and easy to prepare as he does not like cooking or putting effort into budgeting.

4. First generation prototypes

As a result of our review of related work, we extracted a set of key features and concepts to incorporate into our first generation prototypes, focusing on increasing user engagement via the persuasiveness of the applications and incentivising users to engage with the application in the long term. Such behavioural change is vital to encouraging healthy lifestyle habits and fulfilling our users' requirements.

One of the ideas we considered was incorporating a social functionality to the mHealth application prototypes, as their importance was prevalent in our findings regarding determining user behaviour by social comparison and social support (Michie, Johnston et al, 2008).

Another trend we noticed was that users prefer simple, easy to use interfaces with fewer features than poorly designed interfaces with an overwhelming amount of features. This makes users more likely to continue engaging with the application, thus exposing them to persuasive technology for longer and encouraging the upkeep of healthy habits by the users (Michie, Johnston et al, 2008) (Oinas-Kukkonen and Harjumaa, 2009).

Providing the user with trustworthy and relevant information, through in-built libraries is also highly beneficial, based on the assertion in *Mapping Theoretically Derived Behavioural Determinants to Behaviour Change Techniques* that informing a new and inexperienced user will encourage continued use of the application and maximise the nurturing of sustained healthy behavioural change. Additionally, the most successful application as evaluated in *Evidence-Based Strategies in Weight-Loss Mobile Apps*, owed its success primarily to an in-app library of information.

4.1. Prototype 1

The minimalist design of this prototype aims to maximise functionality by maintaining a simple easy-to-understand interface. The design includes a limited number of features, inline with Michie, Johnston et al., which suggested that users prefer simple design to excessive functionality. The user's input is restricted to the most essential information required by the application. Addition, helpful information is displayed prominently for the user to review. The personalised tips are sorted by importance to restrict the volume of information presented to the user.

❖ Home screen

The homepage takes a minimalist approach by showing recognisable icons to symbolise the achievements, exercise, nutrition, social and settings pages. This page is linked to most of the other interfaces within the application. The homepage is customisable as different users may want to have easy access to different features. For example a user may not wish to connect their social networks to the app. Then, the social tab would be unnecessary for them.



❖ Exercise input

Information in the exercise tabs is help to a minimum. The screen simply shows the type of exercise at the top, a stop clock and a start/stop button. The app automatically calculates the number of calories a user has burned during a particular exercise after the user has recorded the activity, which is especially useful for casual users focused on improving their habits rather than focusing on their workouts. The pace and distance are calculated based on the user's GPS location.

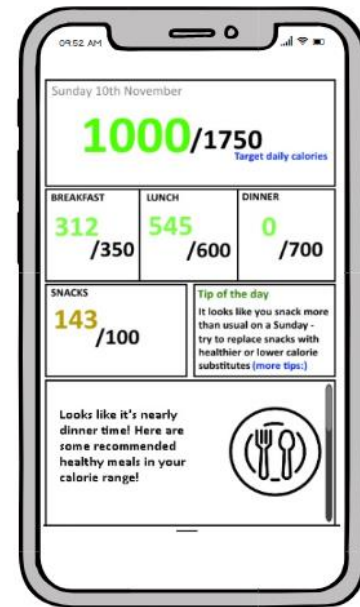


When a user has successfully recorded an exercise, the application presents the result screen on the left. The screen presents information about the time, distance, pace and number of calories burned during the exercise session. Both screens in this section focus on functionality and simple easy-to-use design.

❖ Nutritional information

Tailored towards casual monitoring of calorie intake, the food interface offers gentle tips and meal suggestions aimed at cultivating general healthy eating habits. Splitting calorie intake up by meal allows the user to easily spot where unhealthy habits are concentrated. The tip based on user input highlights trends in their behaviour. The interface relies on the correct input of calories by the user and does not offer additional information about the food intake (such as macronutrients) in order to not overwhelm the user with information.

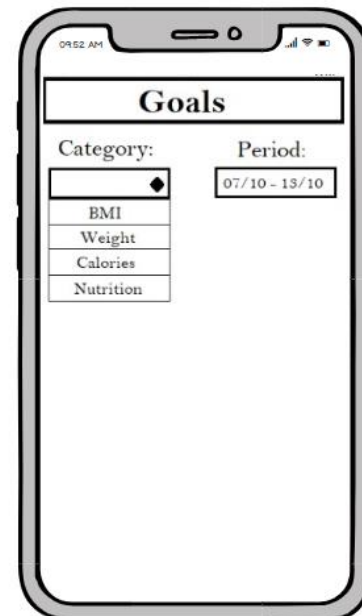
The overall daily allowance is based on the user's goals. The interface also allows for snacking and allocates a certain amount of calories for them to encourage reducing them, as opposed to completely cutting them out, introducing a more gentle approach for new users.



❖ Goals

This tab contains all the information the user has about their progress instead of breaking it into sections. The simplicity of the design allows for the clear presentation of data in a simple and easy-to-read way. The page does not aim to motivate the user, as it relies on the user's commitment to continue engaging with the app.

The user can choose which of the given options in the drop down menu they would like to see their progress for: BMI, Weight, Calories or Nutrition. Different users might have different goals and be interested in one or more of those.





In order for the advice to be perceived as reliable the screen does not use visual cues to motivate the user, but opts for presenting the information in text. The clinical tone, white backgrounds and link to external resources all lead the user to perceive this information as trustworthy. The interface focuses on providing the user with precise information about their caloric intake (on a weekly basis) and recommendations about their nutritional needs.

The user can choose a specific time period (on a weekly basis) for which they would like to receive additional information about. When the user interacts with that option they would be presented with a calendar in order to choose the appropriate week.

Some colour coding is used within this screen to highlight the elements of the recommendations that are measurable as good (Green) or bad (red).



Alongside the information about their nutrition and caloric intake, the user is also presented with information about their weight goals and current BMI. Here, the user has the option to share their progress on their social media profile if one is linked to the app.



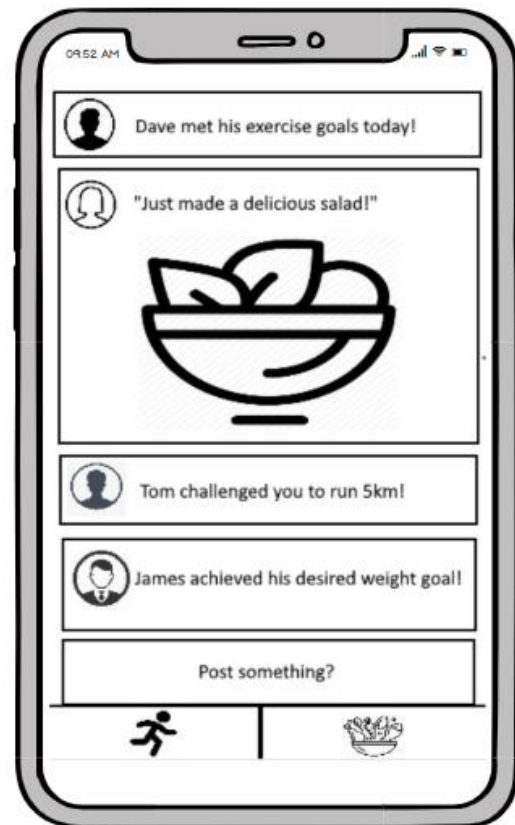
4.2. Prototype 2

Our second prototype takes into account the importance of personalisation. Recognising that our potential users come from various backgrounds, we have created an interface that is highly adaptable in relation to their goals. This prototype ideally caters to someone like Ben Davis, who feels limited by their budget. The detailed tracker of nutrients and exercise planner also suit our persona's desire to introduce different exercise routines into their life and the importance of macronutrients to their diet.

The social features allow the user to feel as part of a community. The competitive rankings and personal achievements pages are suitable for both Ben's need to show off his progress with his friends and Ellen's outgoing nature. The social feed also encourages the users to engage with the application for a prolonged period of time, as evidenced in our literature review.

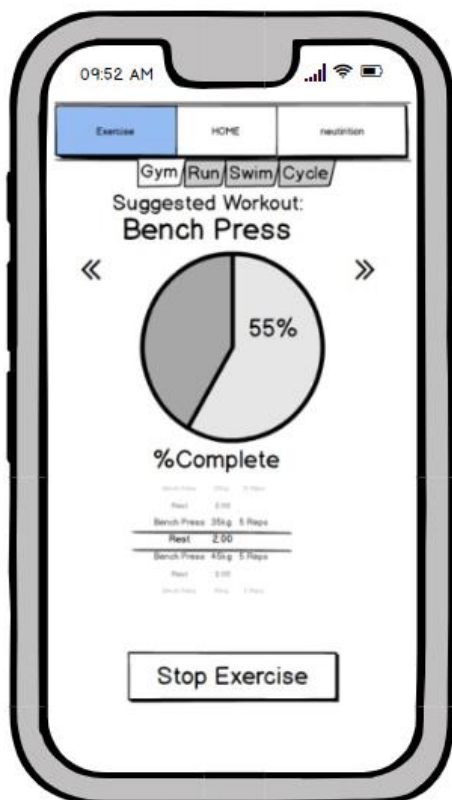
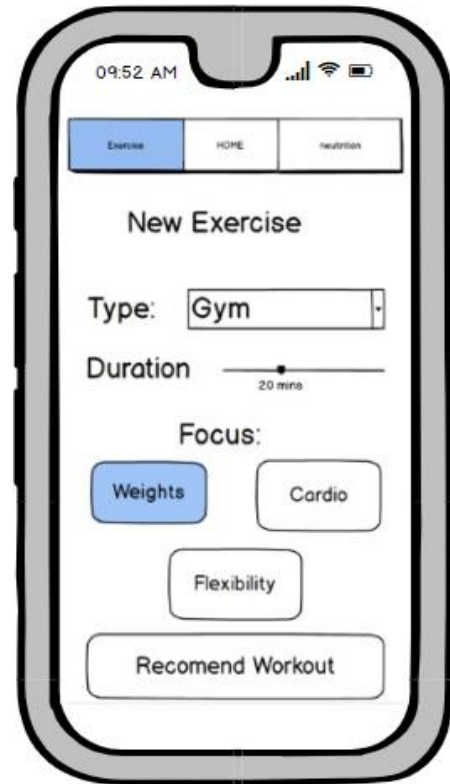
❖ Home screen

The home screen focuses on displaying the social networking features of this prototype. It allows users to easily see stories from their friends and people they follow. The news feed also features recommended articles and posts from health and fitness experts, as well as quick reminders about meeting diet/exercise goals and how to better achieve them. This would allow for users to get the latest in fitness advice quickly and clearly. The central features of the app, the diet and fitness trackers are located at the bottom of the home screen for easy access and are heavily integrated with the social network feed.



❖ Exercise input

This screen allows the user to create a new workout plan for themselves based on the amount of time they have, their focus (weight, cardio or flexibility) and the type of exercise they would like to perform. The suggestions the app will make are based on the previously collected data from the user's input. The use of sliders, large buttons and dropdown menus emphasises the simple design and makes the interface accessible. No text input is required to avoid complications and prevent error.



While the user is completing an exercise, the interface will be presented with useful and encouraging information such as %completion, the current exercise and an outline of the exercises to come. Design is fairly minimal as data is difficult to read during a workout. Depending on the type of exercise, the screen might vary, however, it will always be specific to the type of exercise. The amount of detail is preferred by users who are fairly serious about their exercise regiments. The list shows the upcoming and past exercises in this session. The pie chart illustrated for much of the exercise has been completed so far.

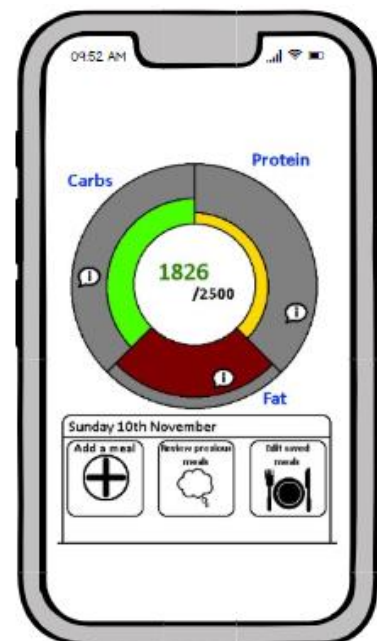
When a workout has been completed, the user is presented with easily accessible data. Detailed information is provided for every exercise, allowing the user to better understand their performance and track their progress overtime. The screen also shows goals and records for the workout and provides the option to share the workout with friends.

The top bar highlights any achievements and the total exercise time.



❖ Nutritional Information

Offering not just a calorie target but also a breakdown of macros, this interface works best for someone who wants to change their weight in a particular way. This interface provides live-updated meal suggestions based on what the user has already eaten that day and their current macros is a highly useful feature for someone who has more targets than simple calorie intake to consider. Colour-coding the macronutrients (red representing the user has consumed more than their daily allowance and green representing that the user's on track to achieve their daily nutritional goals) presents the information about the user's macronutrients in a easy-to-read, graphical way.



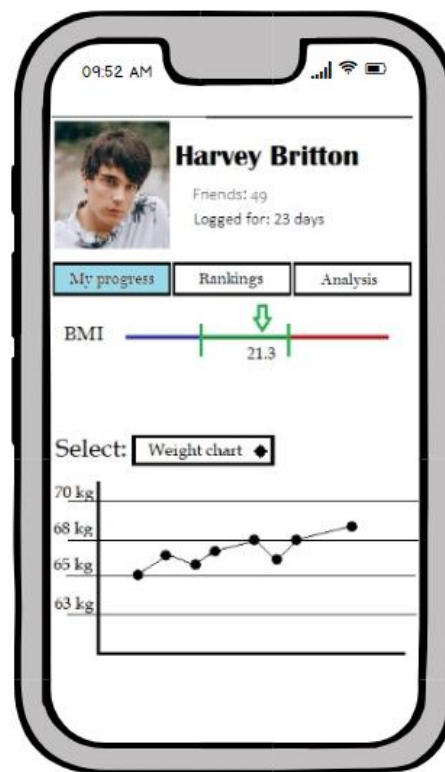
❖ My progress/Rankings/Analysis

The emphasis of this feature is on creating a community around the app. Users have an account associated with the system, which may or may not be connected to other social networks. The user profile will include an option to add friends, a ranking system of the user and their friends list, as well as the option to share information publicly (both within the app and outside of the app on external platforms).

‘My Progress’ tab shows different aspects of the user’s progress. Users have the option to select from the following list: Weight Chart, Caloric intake, Exercise.

BMI is displayed alongside the charts mentioned above regardless of the choice of the user.

In this example the weight chart shows the overall progress of the user over time while using the application.





‘Caloric intake’ feature allows the user to see an overview of their weekly intake in a visual way.

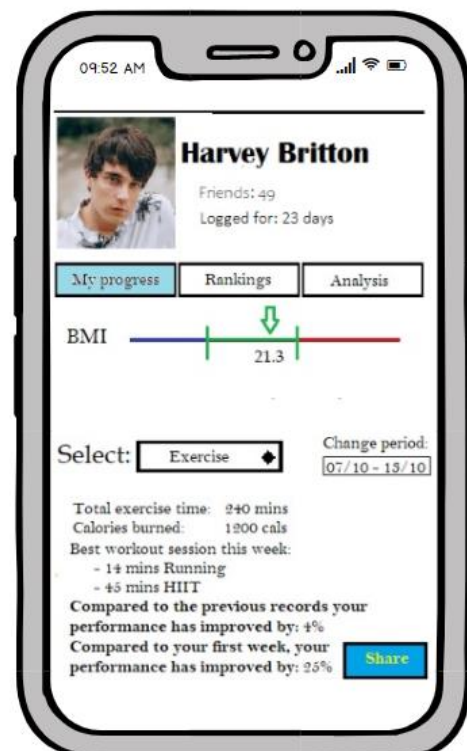
They can change the period to any week for which data is available, including the current week. Where data is not available, the chart would not show data for that particular day.

The colour-coding system follows the same pattern as the BMI scale: Green is healthy, Blue signals undereating and Red - overeating. The values are calculated based on the user’s daily caloric goals, shown in green (here, 2100 cals).

In the ‘Exercise’ section, the user is offered with a weekly overview of their exercise record. As consistent exercise is more important than the daily values, the illustration of exercise takes a different approach and focuses on the overall weekly exercise time and calories burned.

The user is also provided with information about how they are progressing with their performance. This would be calculated differently according to the interests of the user and their preferred exercise methods.

Additionally, the emphasis on social media is also prevalent here with the option to share the current



performance progress compared to the first week the user logged their exercise.



The Ranking function allows the user to compare their progress to their friends.

The ranking system's aim is to motivate the user to improve and achieve better results in order to 'get to the podium.'

The app also shows the user the people ranked directly above and below them are, so they can have a clear idea whose progress is similar to theirs.

The 'Analysis' section shows some of the recent activity on the user's profile and provides them with the opportunity to share some of their achievements. The information covers a range of topics from healthy habits to results of the ranking and progress information.

The 'Analysis' is automatically generated in order to save time for the user if they wanted to share something with the community. It encourages engagement with other users and a sense of community around the process of losing/maintaining/gaining weight.



4.3. Prototype 3

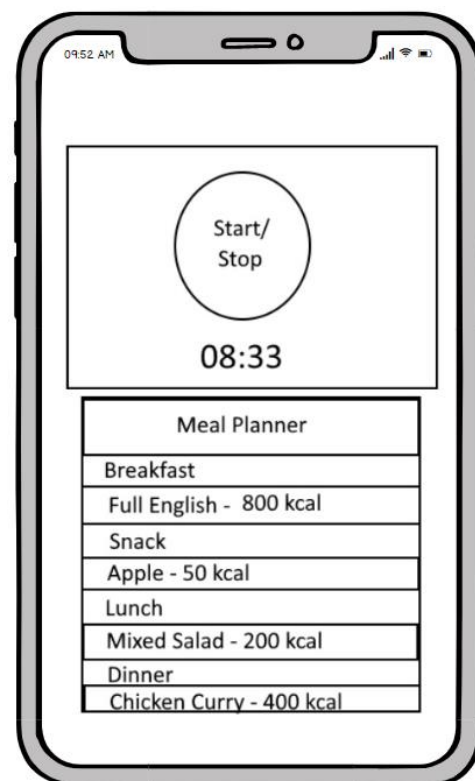
Our third prototype focuses on a user-friendly approach with simple, easy-to-use navigation and emphasis on encouragement. The positive tone of the system aims to engage the user using positive reinforcement and is particularly suitable for someone, who has little to no experience with health related applications before, as well as people who lack confidence or knowledge about healthy eating. The prototype intentionally provides little detail about the user's intake, as the potential users might find the information overwhelming or not be interested in a great level of detail like tracking of macronutrients. The prototype is also suitable for people, who want to quickly and easily add data but are not going to engage with the application for longer periods of time like our personas Harvey and Ellen.

❖ Home screen

The home screen provides relevant daily information and a quick way to record a new workout. This would be well suited to those with free time in the evenings to fill out the planner but with limited time during the day.

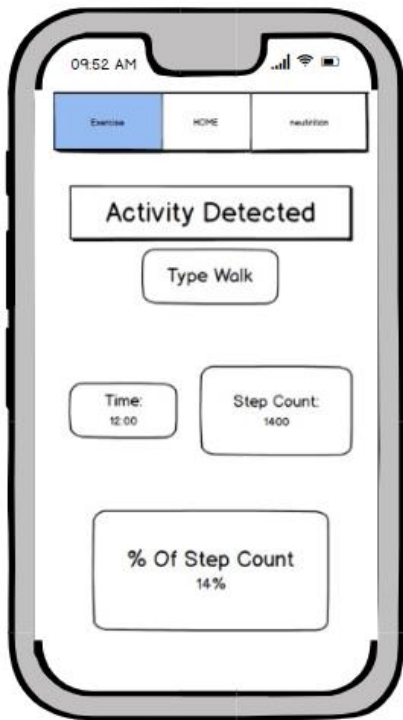
The meal planner consists of the food consumed during a particular day. The information is to be input the day before consumption and then confirmed the following day when the user has the respective meal. This icon is a short cut to a more detailed food and diet planner.

Once an exercise has been completed the user will be taken to a more detailed page, focused on exercise (shown below).



Other features of the app would be accessible from a main menu rather than being directly available from the home screen.

❖ Exercise Input

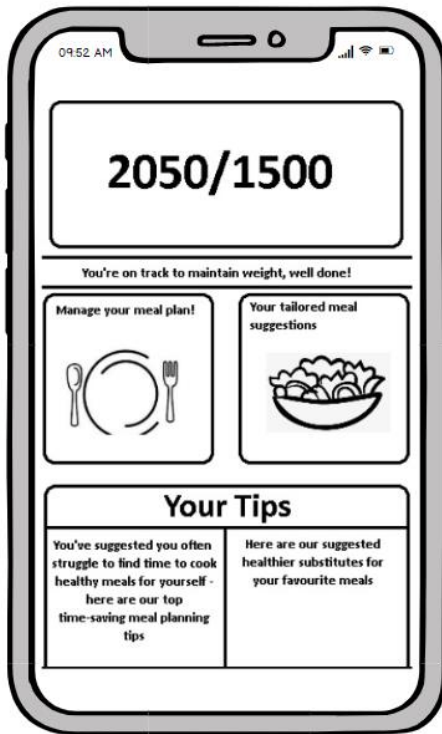


This screen has automatically detected that the movement of the user, identified the movement as walking and is calculating the time of the activity and counting the number of steps. Both of those are demonstrated on the screen. This kind of exercise ‘input’ requires no direct interaction with the device. As a trade off, the number of exercises this interface can track is greatly reduced and the phone must be on the person. The advantage of such a system is that it allows people who are not that interested in exercising to log their movement throughout the day. It also prevents the user being overwhelmed by huge amounts of data.

Once the exercise has been completed, the app will automatically track the end of the activity and the user will be presented with a competition screen like the one on the right. The screen will show an encouraging message to the user, alongside information about the activity they have completed.



❖ Nutritional information



With a focus on encouraging the user rather than demotivating them, this interface would help foster healthy habits and sustainable weight loss in people with time or budgetary limitations. This interface offers tips and tailored meal suggestions relevant to the user that encourage healthy eating.

‘Your Tips’ section showcases digestible and quickly-accessible pieces of information responding to previously recorded behaviour. The interface doesn’t offer more specific management of macros and focuses primarily on encouraging developing healthy habits.

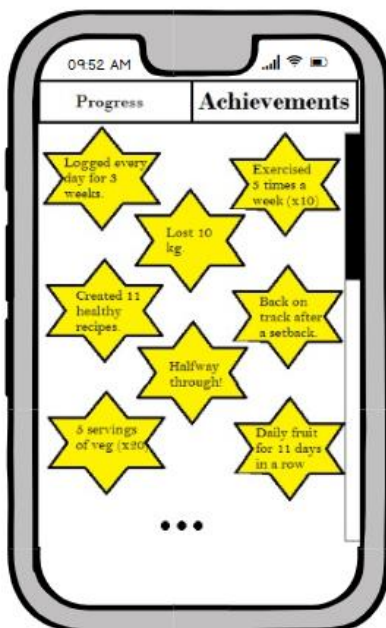
❖ Progress/Achievements

The emphasis here is on encouraging user engagement through visuals, positive language and colourful interface. The aim is to motivate the user to keep tracking their progress.

The 'Progress' tab reflects on the user's progress so far, showing them how much they've lost (here, measured in dogs) and illustrates the number in a visual way. The emphasis is on encouragement and visual stimuli.

This version also lists some 'Recent achievements' to emphasise the progress the user has made while using the app.

The design is not focused on graphical representations or numbers. Instead it takes a more user-friendly approach and encourages the user through positive language.



The achievements screen shows the healthy habits the user has developed/ sustained over time.

Each star represents a single achievement and the achievements cover different areas of a healthy diet – eating fruits and vegetables, creating healthy recipes, exercising, as well as milestones in terms of weight loss/weight gain.

The focus is on encouraging the user to continue their healthy habits in order to increase the number of achievements, rather than focusing exclusively on the amount of weight lost/gained.

4.4. Evaluation of the first generation prototypes

The methodology we have chosen to evaluate our prototypes is based on Nielsen and Molich's 1990 article, *Heuristic Evaluations of User Interfaces*. This provides a version of earlier heuristic evaluation models simplified by 'two orders of magnitude,' making it an appealing foundation from which to develop a methodology. As Nielsen and Molich's framework is aimed at heuristic analysis of completed interfaces rather than prototypes, we can disregard a certain number of the ten usability heuristics they suggest. Our reasoning for including (or not including) certain usability heuristics is as follows:

The following heuristic evaluations were included in our evaluation due to the corresponding reasons:

- **Visibility of system status:** Vital to the tracking of food and exercise for the user to be able to see a change in the system once they have inputted data. Other elements of prototypes for which this is important are settings pages (so a user can ensure that a desired change to the system has been made).
- **User control and freedom:** Important for interfaces reliant on user input for the user to be able to 'back out' of incorrect inputs easily.
- **Consistency and standards:** A prototype that fails to make its interfaces feel connected is fundamentally flawed. Consistency across interfaces is also important for usability, as it makes using subsequent interfaces easier, if the user has used similar mechanisms already.
- **Recognition rather than recall:** A prototype is more user-friendly if it relies on recognition rather than recall. This is especially true for systems with a large degree of functionality, various functions and navigations.
- **Flexibility and efficiency of use:** Important measure of how well the system tailors itself to regular and new users alike.
- **Aesthetic and minimalist design:** As shown in the literature review, users prefer simplistic design over excessive functionality and are encouraged to continue using apps that are aesthetically pleasing.

- **Match between system and the real world:** Broadens the base of potential users, who are likely to understand the application intuitively.
- **Error prevention:** As the prototypes will rely heavily on user inputted data, preventing the user from inputting incorrect information via drop-down menus, fixed input options or situation-specific keyboards is essential.

The following heuristic evaluations were not included in our evaluation due to the corresponding reasons:

- **Help users recognise, diagnose and recover from errors:** Interfaces should be developed to prevent all errors, negating the need for error prevention, diagnosis and recovery.
- **Help and documentation:** The aim of our system is to be intuitive, thereby negating the need for external help or documentation.

The methodology

From our chosen heuristics, we decided on a 6-point (from 0 to 5) rating system, where 0-1 indicates that a prototype fulfils the requirement very little or not at all, 2-3 indicates that a prototype fulfils the requirements somewhat and 4-5 indicates that a prototype fulfils requirements well or completely. This provides some room for nuance within score categories, while keeping those categories well defined. We then provided specific evaluative comments for each of the prototypes based on our conclusions drawn from the evaluation tables.

Nielsen is clear that having only one person heuristically reviewing leads to unsatisfactory results, as ‘individual evaluators were mostly quite bad at doing such heuristic evaluations.’ (Nielsen and Molich, 1990:249) Nielsen suggests that taking an average of several heuristic evaluations improves outcomes even if an average is taken from a group of ‘only 3 to 5 people.’ For the evaluation of our first generation prototypes, we followed the framework,

choosing three evaluators to assess each prototype individually and a value for each of the selected heuristics within the scoring system defined above.

a. Prototype 1:

Heuristic	Evaluator 1	Evaluator 2	Evaluator 3	Average
Visibility of system status	3	3	1	2.33
User control and freedom	2	3	1	2
Consistency and standards	2	1	0	1
Recognition rather than recall	2	1	3	2
Flexibility and efficiency of use	4	4	0	2.67
Aesthetic and minimalist design	0	1	2	1
Match between system and real world	2	1	0	1
Error prevention	2	2	4	2.67

Total Score = 14.66/40

Comments:

Prototype 1 performs poorly achieving only 37% of the possible marks. Overall, the majority of the features ‘fulfilled little or not at all’ or ‘fulfilled somewhat’ the characteristics. None of the features had a high score on their performance. Flexibility, efficiency of use and error prevention are outlined as the best features of this prototype, while error prevention – the worst.

The strength of this Prototype comes from its high level of customisability in the home screen and the variety of data accessible from the goals screen. This allows for a decent score in flexibility and efficiency of use as the user is able to tailor the layout and data provided based upon their own personal preferences.

The prototype is inconsistent between interfaces and many of the interfaces suffer from clutter, leading to a lower score for consistency and aesthetics. In particular, the food and exercise screens look very different with a completely different way of inputting data, which can be confusing to users who may struggle to learn and adjust between these methods.

The utility of the prototype is also limited by restricting the inputs from the exercise and food screens. The exercise section in particular is very limited with the user only being able to record four different types of exercise with no explanation of what the user is to input if they’re performing an exercise that isn’t listed. The recording of data is based solely off of a start/stop function to time the exercise and automatic GPS tracking to determine pace, which leaves little room for more relevant data to be input by the user. This also may lead to additional errors owing to technical failure such as GPS malfunction or app crashes. Additionally, if a user forgets to input an exercise whilst doing it, there is no way of going back and inputting it manually, meaning that the exercise isn’t recorded at all, leading to inaccurate data. This is also inconsistent with the food interface, which relies entirely on user input data.

Although, the restrictions placed on exercise input help with error prevention as users are less able to input incorrect data. However the purely manual inputting for the food intake leaves room for user error. There is nothing to prevent users from recording incorrect values in the food screen.

There is also little in the way of real world similarities for many of the interfaces, with it being entirely absent for most interfaces and only having a small presence in the icons for food, exercise, achievements, etc in the home screen and food screen.

b. Prototype 2:

Heuristic	Evaluator 1	Evaluator 2	Evaluator 3	Average
Visibility of system status	4	4	3	3.67
User control and freedom	2	1	3	2
Consistency and standards	1	0	0	0.33
Recognition rather than recall	2	1	3	2
Flexibility and efficiency of use	3	3	3	3
Aesthetic and minimalist design	1	3	2	2
Match between system and real world	1	1	2	1.33
Error prevention	2	2	4	2.67

Total Score = 17/40

Comments:

Prototype 2 scored the best out of the three first generation prototypes, despite scoring less than half the possible number of marks. Its relatively high score is mainly due to the prototype performing well in the first, fifth and eighth heuristics.

Visibility of system status is prototype 2's best heuristic. This heuristic is somewhat-to-well implemented and aided by its well fleshed out progress and achievements interface(s). Throughout the app the user can easily review inputted data and see the status of the system. In regards to the food and exercise input interfaces, both of which feed data to the progress and achievements interface(s), a user can locally view information regarding system status (such as the progress wheel for a workout or a large 'stop workout' button to indicate that the system is currently recording a workout).

The section related to food and nutrition for prototype 2 was also a factor in its high score, as it provides a means to review inputted data on the same interface as the input location itself. Prototype 2 is still arguably under-developed in this regard, with functionality to review certain inputs being severely limited and therefore adding extra steps to verifying system status.

Flexibility and efficiency of use is also rated relatively high for this prototype. Its strengths in this heuristic lie in the food interface, which allows the user to save meals and therefore not have to re-input the same things over and over again. However, it is limited by the exercise interface, which allows only for the input of a certain number of exercises within three broad categories (strength, cardio and flexibility) from a drop-down menu. Moving forward, every interface should try and adopt the strengths of the food interface in terms of flexibility and efficiency.

The obvious weakness of this prototype is in the 'consistency and standards' heuristic. The reasons for this are fairly obvious - not only do common objects like buttons and tabs vary from interface to interface, but navigational UI items like tabs vary wildly. This severely weakens the convincingness of the prototype, and renders the prototype as a group of unrelated interfaces more than a prototype for a completed, internally consistent application.

c. Prototype 3:

Heuristic	Evaluator 1	Evaluator 2	Evaluator 3	Average
Visibility of system status	1	2	1	1.33
User control and freedom	2	2	1	1.67
Consistency and standards	1	3	0	1.33
Recognition rather than recall	3	3	0	2
Flexibility and efficiency of use	2	2	0	1.33
Aesthetic and minimalist design	2	4	0	2
Match between system and real world	2	1	0	1
Error prevention	1	0	2	1

Total Score = 11.66/40

Comments:

Scoring the lowest overall, prototype 3 offers no protection against unwanted automatic input detection on the exercise interface (wherein this is the only kind of exercise tracking available) and no easy way for the user to change their meal plan if they eat something different from what they have planned. User control and freedom is also severely lacking. As mentioned before there is no non-automated exercise tracking outside of the ‘tap to start workout’ on the home interface, which records only the workout duration and makes no calculation as to the amount of calories burned or even allow the user to specify what kind of workout they’re timing.

Visibility of system status is particularly weak in prototype 3. The only real indication that the system is doing anything at all is in the exercise screen, which shows a live percentage of daily step count and whether or not an activity is currently detected. In terms of the other interfaces, there is no way for a user to verify if they have changed their meal plan after snacking, as there is no kind of notification to change meal plan and the responsibility is shifted to the user. As such, the calorie consumption shown is hard to trust.

Areas for general improvement:

Heuristic	Prototype 1	Prototype 2	Prototype 3	Average
Visibility of system status	2.33	3.67	1.33	2.44
User control and freedom	2	2	1.67	1.89
Consistency and standards	1	0.33	1.33	0.89
Recognition rather than recall	2	2	2	2
Flexibility and efficiency of use	2.67	3	1.33	2.33

Aesthetic and minimalist design	1	2	2	1.67
Match between system and real world	1	1.33	1	1.11
Error prevention	2.67	2.67	1	2.11

This analysis has identified clearly the areas where our prototypes can be improved. Consistency and standards are incredibly low across all three prototypes. This indicates a need to change the way in which we design our prototypes in the second generation. The low score for this heuristic was caused primarily by a failure to create a universal navigation system, which linked the interfaces for any of our prototypes. Additionally, the layout and visual inconsistencies across all prototypes are apparent. In order to reflect on this and avoid repeating the lack of consistency in our second generation prototype, we have considered creating mirroring sections for the food and nutrition and exercise input interfaces, as well as having a clear underlying structure to the navigation system.

Aesthetic and minimalist design was also particularly poor, with most interfaces looking cluttered despite the limited number of features. This indicates a need to change both our style of interface design and perhaps review the tools used to create our interfaces.

The low scores of our first generation prototypes in this heuristic evaluation can be recognised as a result of a failure to take design inspiration from existing, real-world equivalents to our desired features - food diaries like the ones we tried to implement into our interfaces exist in the real world, though no effort has been made to use these real-world examples to positively influence our prototypes. The same can be said for exercise planners and pedometers, all of which are implemented to some degree in a prototype, but few of which can be seriously compared to a real-world equivalent.

05. Second generation prototype

5.1. Introduction

The evaluation of the first generation prototypes highlighted several shortcomings that needed addressing. In order to build a more successful second generation prototype, we revisited our research. Particular methods, highlighted in our research that we had not fully utilised in our first generation prototypes include goal related methods, goal review, social support, relapse prevention, user control, actionable notifications, real-world feel and personalisation.

One of the areas that provided particular interest was the implementation of relapse preventative methods. These generally require the identification of situations that increase the likelihood of the new behaviour not being performed and providing strategies to avoid these situations. Our mobile application aims to integrate such support through the use of notifications and the general analysis of a user's historic data trends. We designed the application to be capable of identifying trends in users' behaviour (e.g. noticing days of the week that were particularly unhealthy or detrimental to achieving the user's final goal). If a regular trend appears, such as Sundays involving very little exercise or movement, the app will push several notifications encouraging the user to go for a walk or plan an activity for that particular day in advance. Preventative methods encourage the user to fall out of their unhealthy weekly habit and hopefully begin to adjust their behavioural patterns.

The lack of goal related methods is reflected in our choice to provide a general overview of the user's behaviour, alongside guidance and recommendations about trends in their behaviour. Providing the user with the tools to closely monitor their progress serves as a source of encouragement and motivation. Additionally, as we were revisiting our first generation prototypes, we realised that although our goal was to focus on developing healthy habits in our users, none of the prototypes we had designed was primarily focused on providing the user with enough guidance, recommendations and support to influence their behaviour.


Both our literature review and the evaluation of the first generation prototype highlighted the benefits associated with integrated social features. The research into social support, as well as

social comparison and feedback, all suggested that social pages would provide extremely beneficial methods to adjust users' behavioural patterns. The personas we designed also benefited from using the social features and engaging with a community.

We understand that the needs and preferences of our users might differ, because of how big group of users we are catering to is. In order to cater to this large number of people, we have decided to implement some customisable features, which can improve their ease-of-access, as well as personalised recommendations.

According to the evaluation against user-scenarios, minimalist design is the most beneficial way of displaying information to the user in a clear and easy-to-understand way.

5.2. General overview of the second generation prototype

The infrastructure of this version of the prototype is divided into four main sections: information about the nutritional intake of the user, information about the energy expenditure of the user, a social interface that allows the user to interact with other users and a section dedicated to the user's personal goals, progress and achievements. As we have realised the importance of social influence and the accountability social features emphasise, this prototype incorporates different social features, which aim to encourage long-term engagement with the application. Each of these sections (alongside a general overview of the user's progress accessed via '*Calendar*') is accessible via the side menu. The menu is displayed when a user interacts with the icon () at the top left corner of the screen, which is available to the user at any point while interacting with the application.

In addition to focusing on healthy eating and improving the user's behaviour, the mobile application we have designed focuses on adjusting to the user's needs, preferences and overall progress. With this emphasis on personalising some of the features within the app, we aim to increase the users' satisfaction and encourage long-term engagement. With regards to this, the following features have been implemented into this second generation prototype: *

☐ **Flexible ‘Home’ screen**

The initial screen a user is greeted with when opening the application (after they have created an account) can be personalised to the user’s priorities and overall aims. If a user decides to edit the page, the mobile application will present the user with a range of options for short-cuts to many of the app’s features, as well as some widgets like step counter or daily tips.

☐ **Tailored recommendations**

The user can see their progress in a visually engaging, but informative way. The mobile application provides suggestions after gathering data from the user’s input so far and identifies trends in their behaviour.

Additionally, the user is provided with guidance in terms of both their nutrition and their exercise routine in respectively the ‘*Meal Plan*’ and ‘*Workout Helper*’ sections. The recommended plans can be filtered and sorted according to the user’s preference and priorities.

☐ **Achievements**

The pre-set set of achievements gives the user a collection of tangible goals they can strive towards. This ties in with the social element of the application, as the user is able to quickly share each of their achievements.

*All of the features mentioned in this list are further discussed and explained below.

5.3 Evaluation of the tools used to construct this prototype

The online mockup software Proto.io was chosen for producing our second generation prototype. The software is available online for a free trial without the need to download, and using it is intuitive. This, combined with the three available short video tutorials by the creators of the software, Proto.io was comparable in usability to Balsamiq, which was used for the first generation prototypes. The software also has a number of features that made it a good fit for the high fidelity mockups.

Proto.io comes with a library of icons, buttons and UI elements that can easily be dragged onto interface designs. Paired with the “group” feature, that allowed us to group icons together,

paste them into different interfaces and change them all at once, this meant that elements of interfaces were consistent across the prototype as a whole. In Proto.io's library interface elements range from UI components taken from real applications and phone operating systems (e.g Apple IOS, Android), which gives created interfaces a real-world feel. Coupled with this, the software allowed for the creation of "containers", interactive UI components that allowed for scrolling (if we had features that extended out of the bounds of a phone screen, such as the '*Search results*' interface) and selectable tabs to change what information was visible to the user at any one time within an interface. This allowed for far more sophisticated interface design and easily navigable overall prototype.

The software provided demos of interfaces the developers had designed with the software. This provided valuable insight into what could be done with the software and shortened the learning time needed to design the pre-planned features for our prototype.

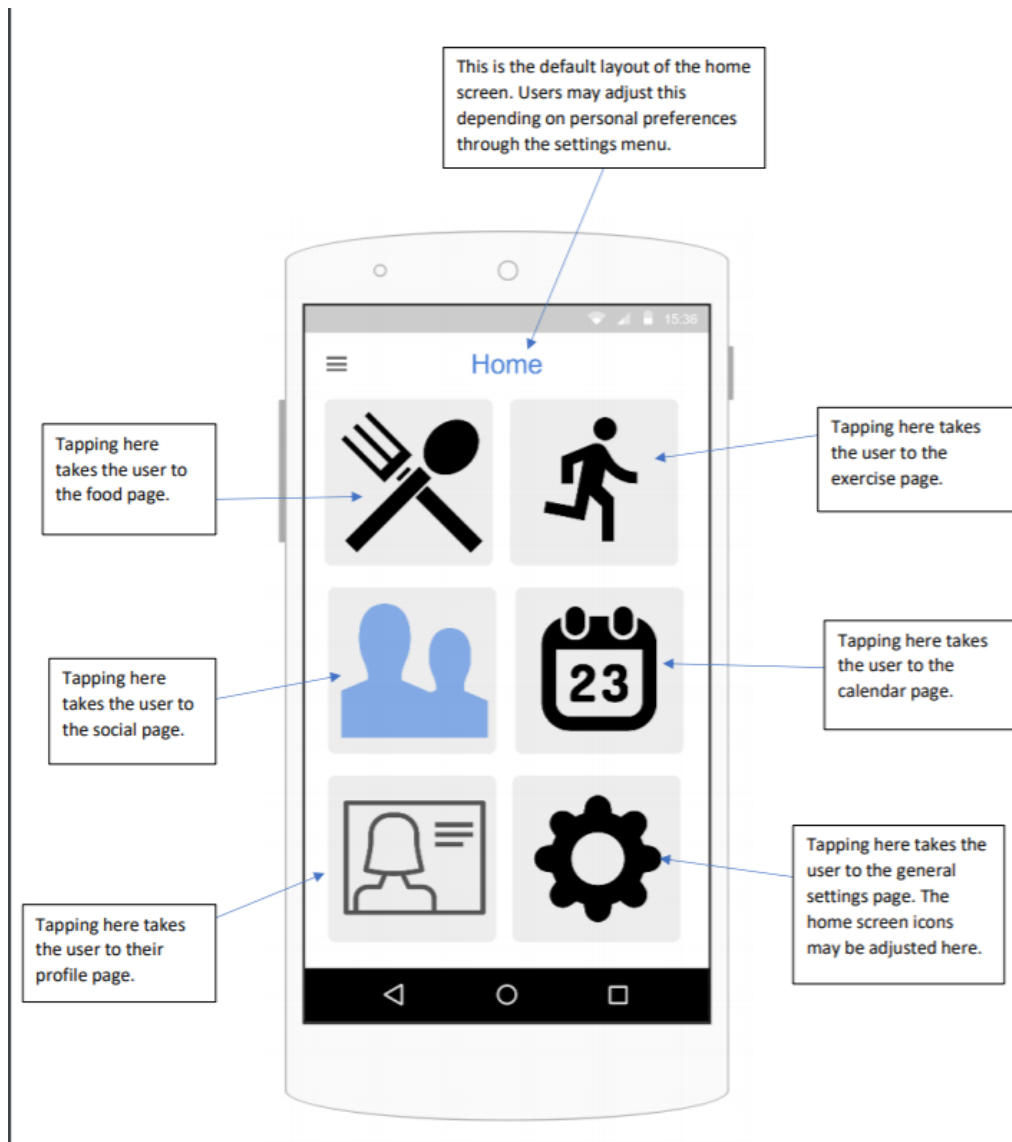
Proto.io also allows for "previewing" prototypes, which means the interfaces can be displayed on a screen as though it were a phone screen, allowing for the testing of the navigation system and consistency of the prototype. This made spotting issues with the interfaces easier and change easy to implement while constructing the prototype.

5.4 Individual features and sections

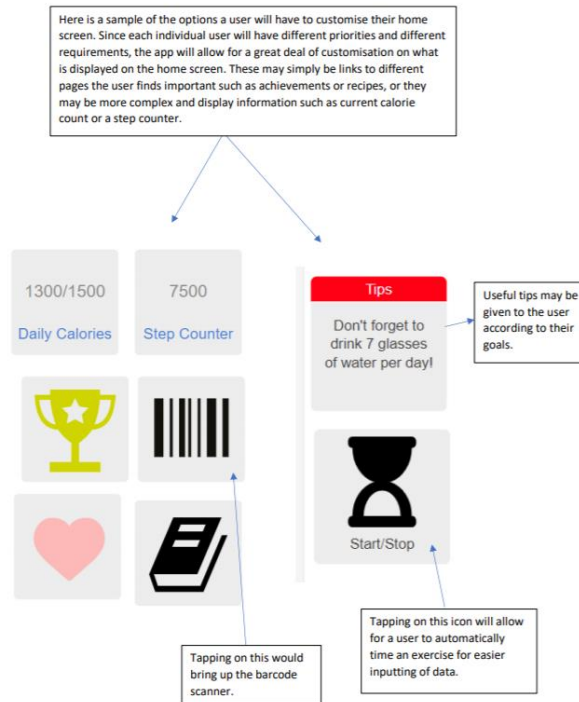
a. Home screen

The Home screen is the first interface a regular user would encounter. The page is fully customisable. Users can personalise the different squares on the page with shortcuts to their preferred locations, a useful step counter, daily tips (that can be general or targeted) and other widgets. Once the home screen has been customised certain features of the application might not be accessible via this page. However, the user would still be able to access them via the side menu.

The default home screen contains links to all the major features of the mobile application: *'Meal Tracker'*, *'The New Exercise Screen'*, *'The Feed'* and *'Profile'* allowing the user to navigate to any of the features of the app through the home screen.



Some of the icons the user can ‘fix’ on their home screen are:

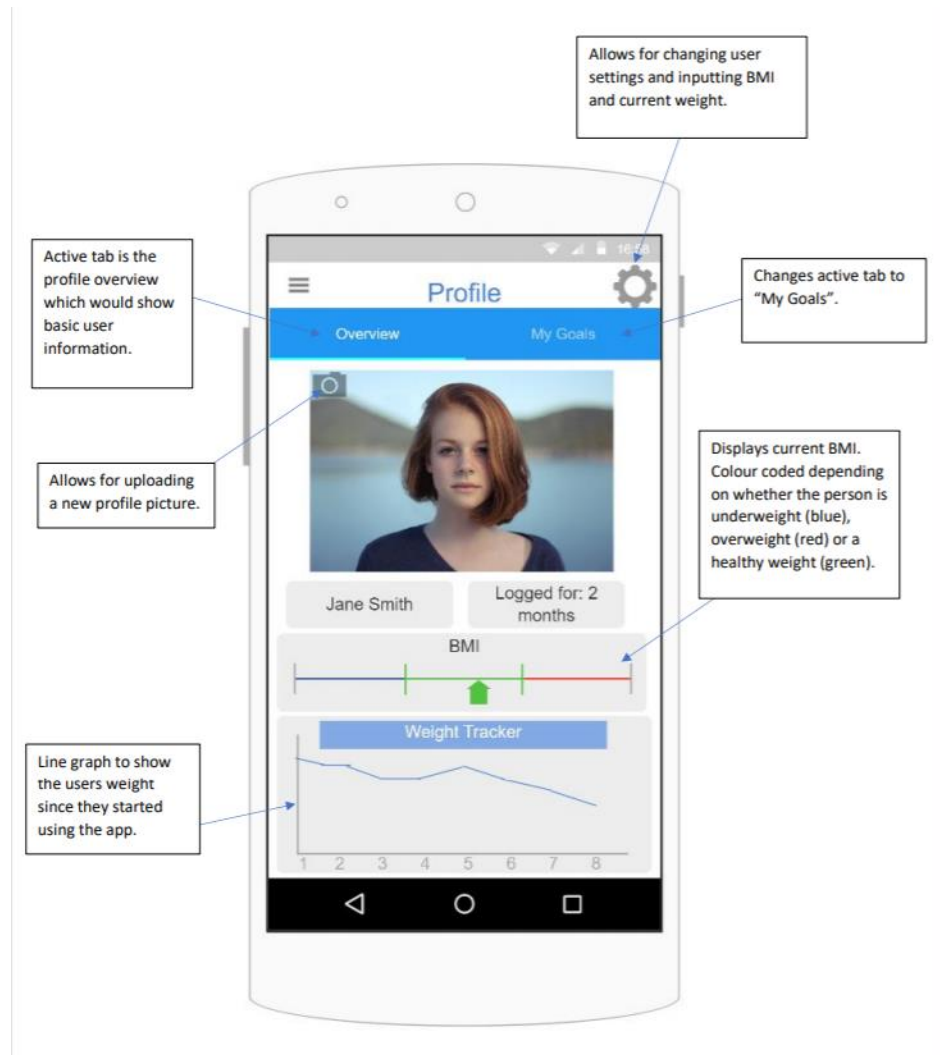


b. Profile screen

The profile pages in this app allow a user to view and set the key information such as weight and goals. The profile section expands to three main screens:

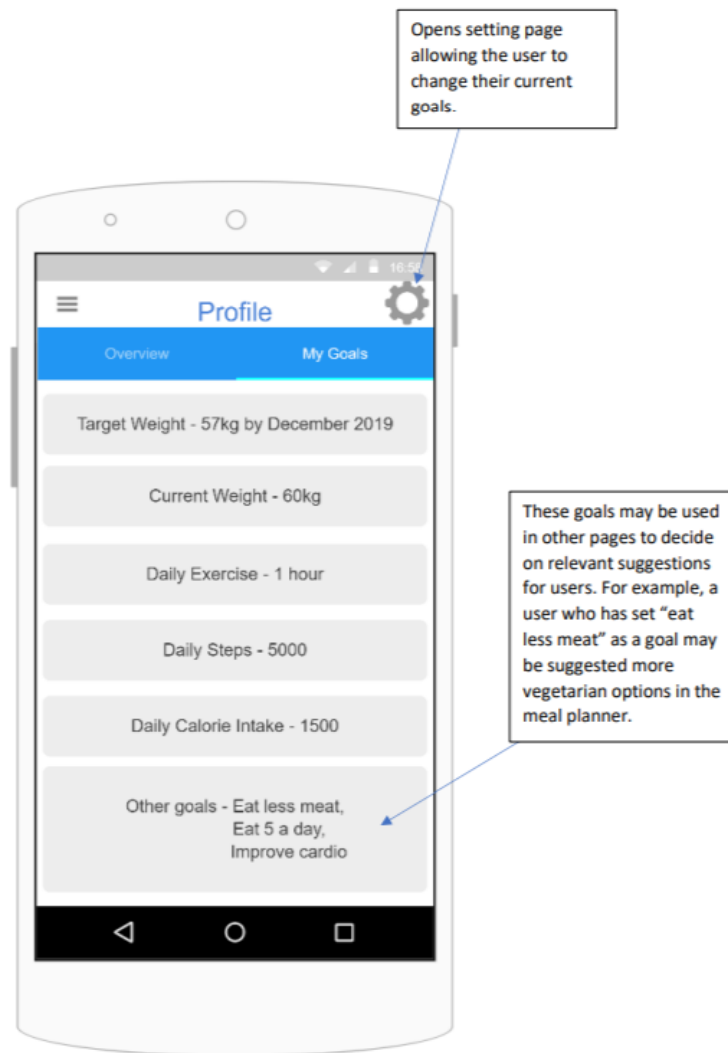
- **The profile overview screen:**

This screen provides the user with an overview of their in-app profile. The page is accessible from the home screen or the side menu. It allows the user to upload a photo, see the length of time the user has been using the app and their current BMI and shows an overview of their weight since they started using the app. The page is limited only to the key information without the clutter of multiple input buttons or fields.



- **The profile goals 'My Goals' page**

This page is accessed through the tab system on the main profile overview page. Again this page is an overview type screen, which shows the user all of their specific health goals. Goals on the app range from long term weight targets to daily exercise or calorific targets. The range is important, allowing the user to set realistic and achievable goals.



- **The profile and goals settings page**

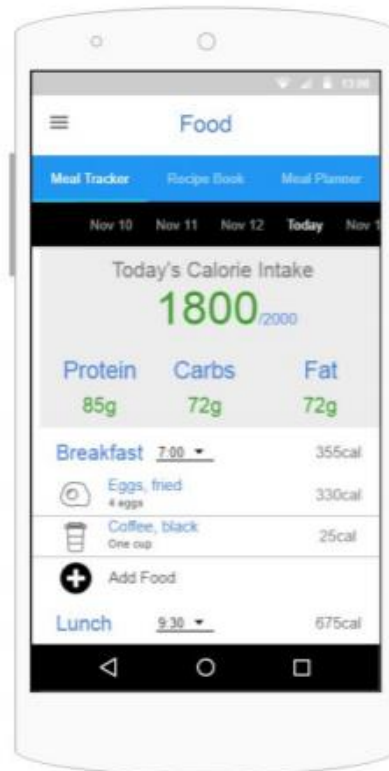
This page is accessed through the cog icon in the top right corner. This symbol was used as it is recognisable, allowing for the user to quickly locate the page without any confusion. This settings page allows the user to adjust all of their information and goals. Goals for target weight in a certain time can be set - the app will assess whether the target is safe and prohibit any dangerously fast weight loss or increase goals. The settings for the social page are also accessible from this location (please note the social settings button found in the social page is simply a link to this settings page). The social settings will allow the user to set profile name and update their

sharing preferences for the social features. The final element of the settings page is the notifications settings, which allow the user to control the type and amount of notifications they receive. The two settings pages are linked to increase the ease of use. The settings screen is a simple standard layout, limiting the amount of data a user inputs manually. It has not been replicated for this prototype.

c. Food and Nutrition section

One of the key features of our prototype is the section related to food and nutrition. The user is able to input their food intake daily, as well as to plan their intake for the next few days. This section features three subsections:

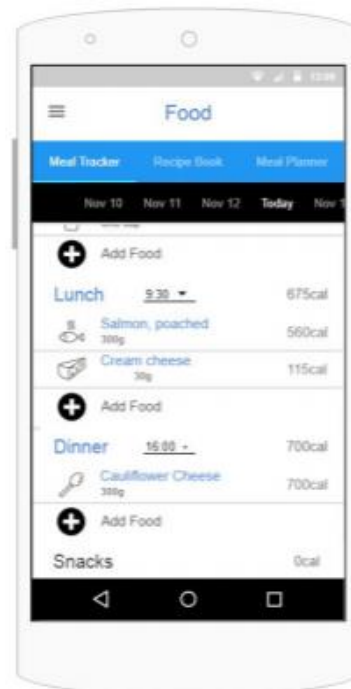
- **Meal Tracker:** This is the main page of the section, which presents the user with an overview of the day. The amount of calories the user has consumed and their daily calorie goal are highlighted on the top of the page. The user can view information about different days via the horizontal scroll underneath the sub-tabs. Each item consumed by the user is displayed alongside its caloric value. The data is then presented with appropriate heading for Breakfast, Lunch, Dinner and Snacks. It is important to note that those headings are customisable, which is to say, if a user wanted to only input Breakfast, Lunch and Snacks they would be able to change the layout of the page to fit their needs. Each heading also clarifies the time when the user has consumed the food. Both when the food was consumed and what kind of meal it was are analysed when the user wants to access information about their behaviour in other sections. For example, if the user is likely to consume food high in sugar late at night, that will be highlighted as a trend.



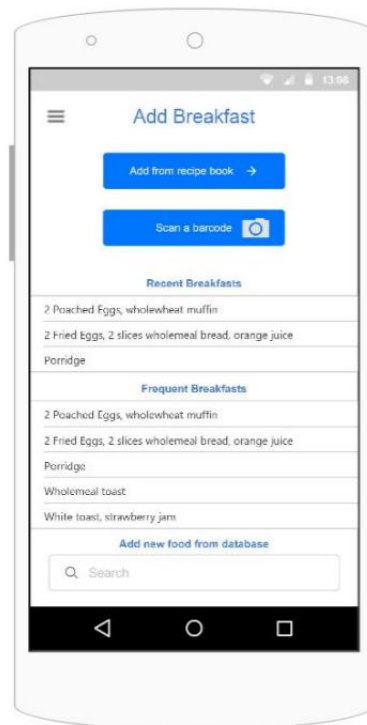
Input separated into 3 meals and snacks separately to encourage both regular meal patterns and to help separate snacking from the rest of the user's daily calorie intake

Sub-tabs to view the inputs of surrounding days or to choose current day

User inputs the time they ate a meal at when they input food, then the next day the app will send them a notification half an hour in advance, both encouraging regular meal times and reminding the user to input their meal while they can still remember what they consumed



- When the user wishes to add a new food item to their diary, they can do so by using the barcode scanner, searching the internal database for a food item or a recipe, or create a new recipe. The application will collect information about the user's input overtime and present a set of 'Recent' food according to the user's previous intake.

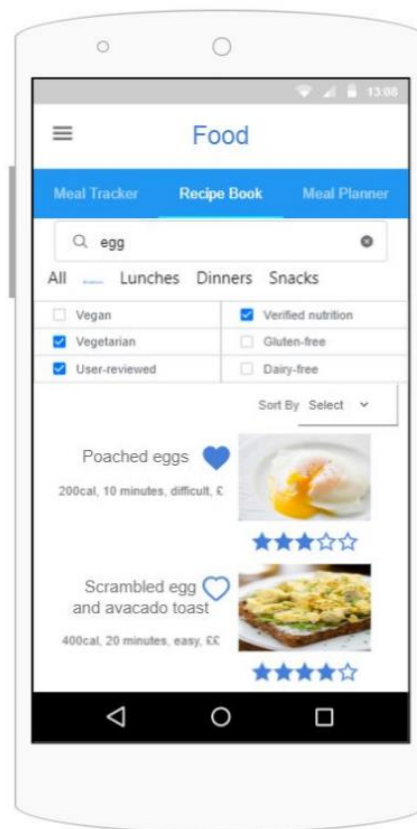


On pressing the black and white "add" button on a meal category, the user is taken to an add food page for that meal category (e.g breakfast).

Here they can either scan food with a barcode or add food from their personal "recipe book"

For convenience, the user is shown breakfasts they've had recently and breakfasts they have frequently to save them scanning barcodes, going to their recipe book or searching the database for them again


If the user wants to input something not covered by previous methods, they can search for foods from the database

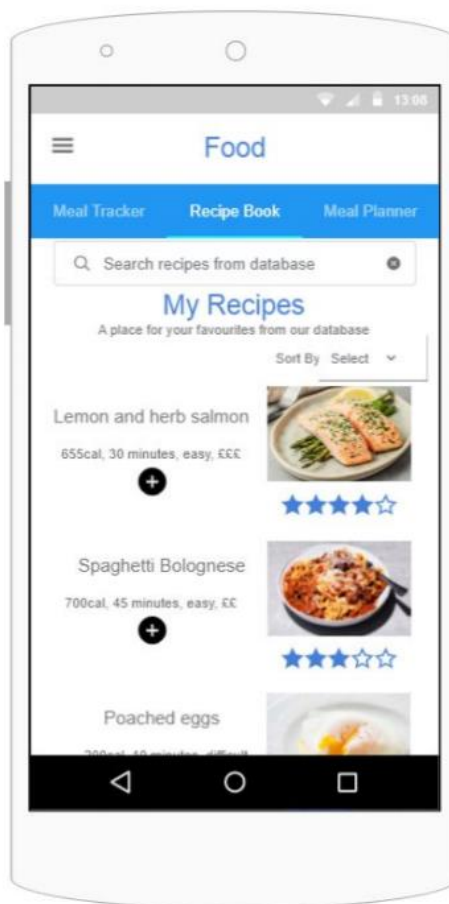


When the user searches for recipe, they can search by meal category (e.g breakfast) and filter by dietary requirements and whether or not their nutritional information is verified, amongst other things

The user can again sort by cook time, difficulty, price and calories, though the search result order will also be tailored to their macro requirements according to their stated goals in the profile interface

The user can add recipes straight from the search results into their recipe book they do not want to look at the full recipe page first

- **Recipe Book:** The Recipe Book functions in a similar way to a real-life recipe book. The user can look up recipes and filter them according to their needs and preferences. The recipes will take into account the budget, experience, calorie count and time required to do each recipe and present the user with various options for their next meal. If they wanted to save a recipe, the user needs to 'favour' the recipe (via the heart button on top of the page ). All recipes that have been added to the user's recipe book can be ordered by the following criteria: budget, experience, calorie count and time required to do each recipe. The user can also create their own recipes and share both recipes they have tried and those they have created.

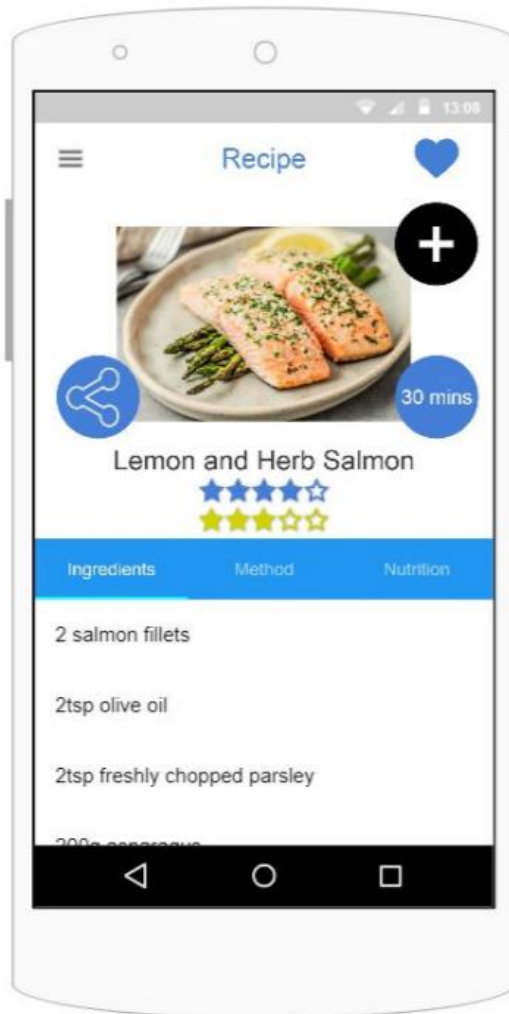


is the user's personal recipe book, re they can easily access recipes that 'have "favourited" from the base. They can sort their saved es by price, time to cook, difficulty to c and by calories by using the drop n box



er can add each recipe to their racker by clicking on the black and "add" button.

ar rating is either the user's own for the recipe or an average of all users' ratings for it if the individual asn't rated it



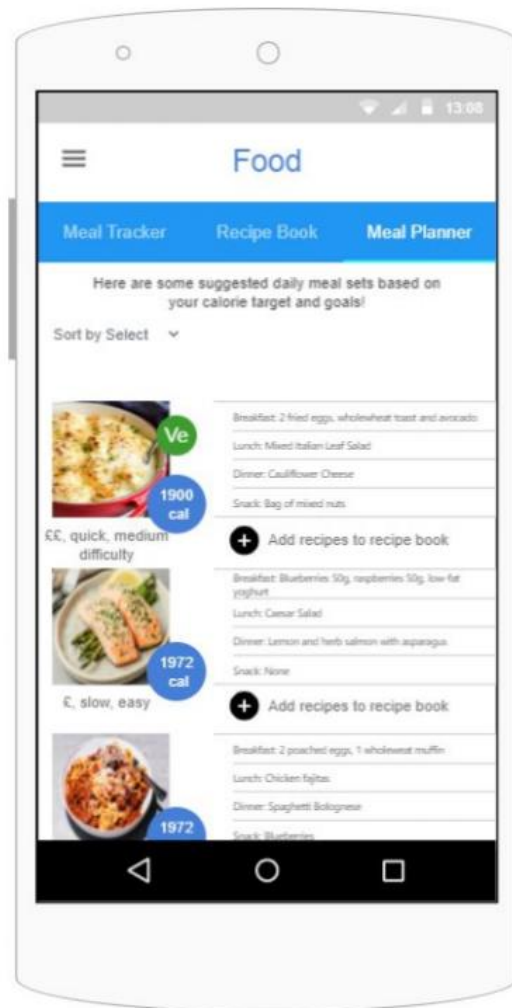
When a user taps on a recipe from their recipe book or the database search, they are taken to its recipe page. Here, they can favourite the recipe by tapping the heart on the top right

The black and white add provides an easy way to add a recipe to the user's meal tracker, and the user has the option to share the recipe to their social page for the benefit of their friends

Here in blue is the average of all user ratings for this recipe, and in yellow the user can input their own personal rating

The nutrition tab offers a breakdown of macros, as well as of calories in this recipe

- **Meal Planner:** This sub-section allows the user to browse different pre-made meal plans. This feature is especially useful for people who have no prior experience with tracking calories, cooking or following calorie limits, as it presents the user with different options to choose from without having to create their own meal plan from scratch. Each meal plan gives the user information about the total amount of calories per day, whether it is suitable for some dietary requirements (Vegan, Vegetarian, etc.) and some guidance regarding the budget, time and difficulty of the recipe. The different meal plans can be filtered according to the user's dietary requirements and or preferences with the drop down menu on top of the page.



The meal planner tab offers a list of potential daily meal plans for the user, based on their calorie targets as well as their goals (e.g strength building) that they set in the profile interface

The user can sort by budget, difficulty and time constraint, though not by calories as the meal plans are based on the user's calorie target and so are all very close in calorie terms

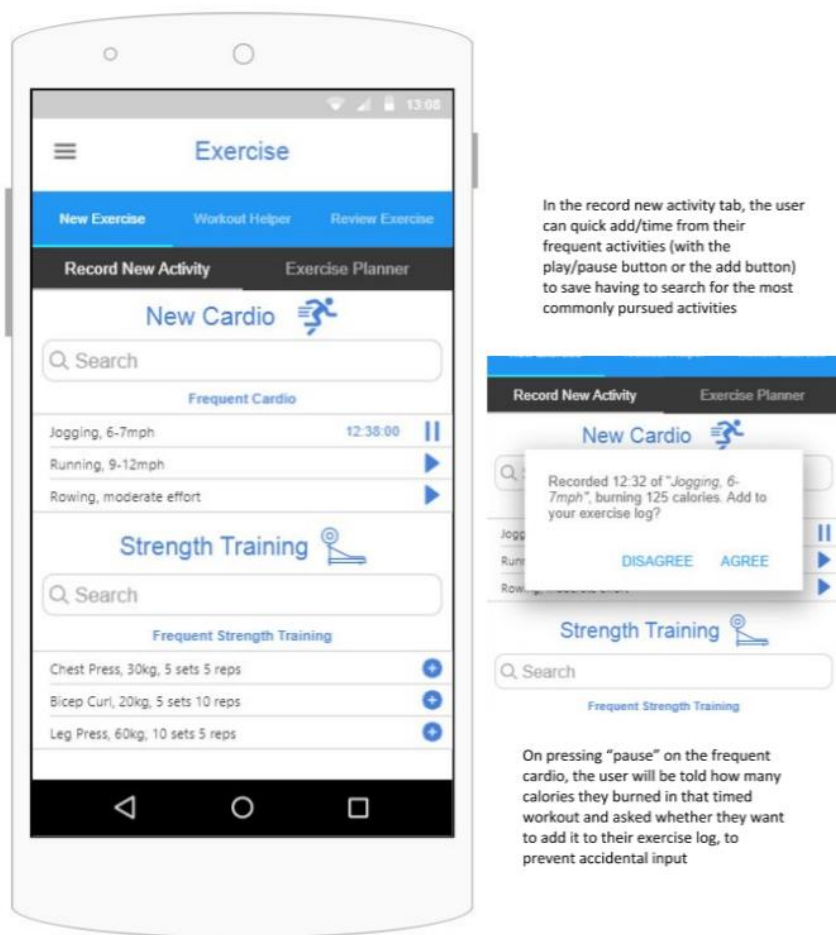
If the user wishes to pursue a daily plan, they can add the recipes to their recipe book so that they can in turn add them to their meal tracker

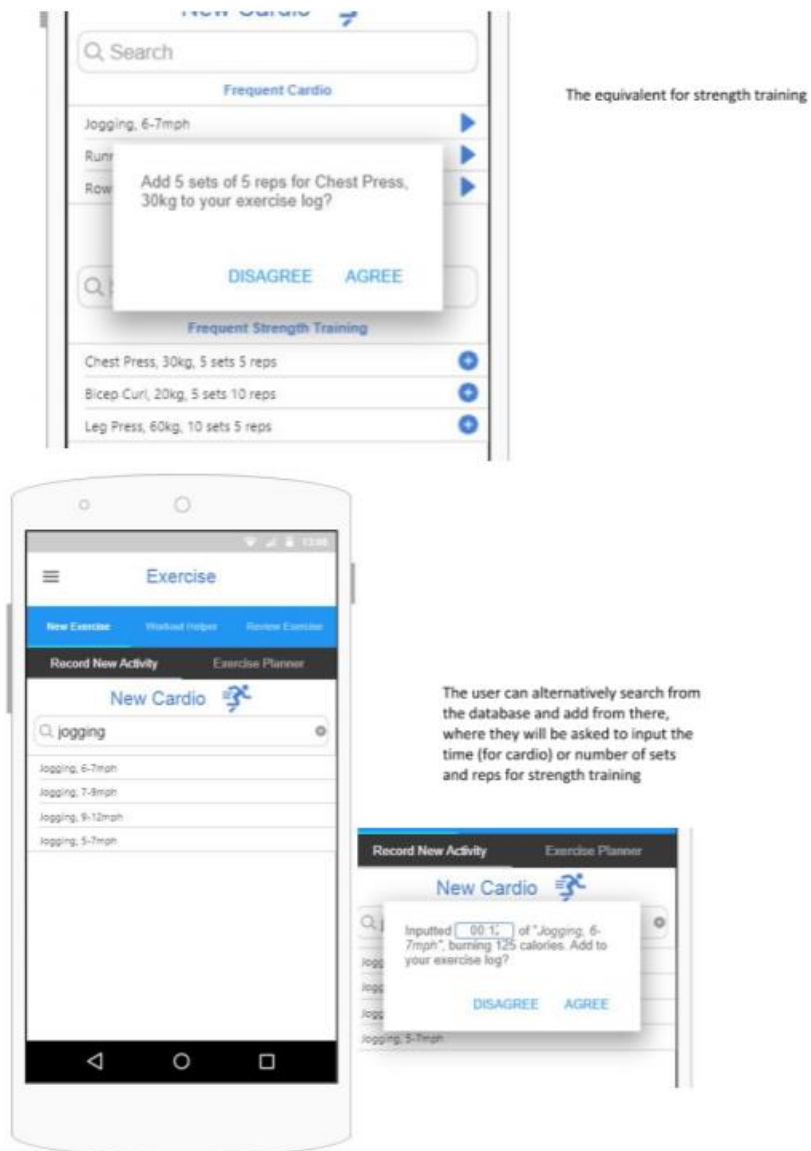
d. Exercise section

The exercise pages of the app are one of the key elements in our prototype. Here the user is not only able to input new exercises but also review past exercises, plan exercises and access an instructional workout helper. The exercise screen will also allow the user to see and adjust any automatically detected exercises to correct for any detection error. There are several key screens in this section of the app:

- **The New Exercise Screen**

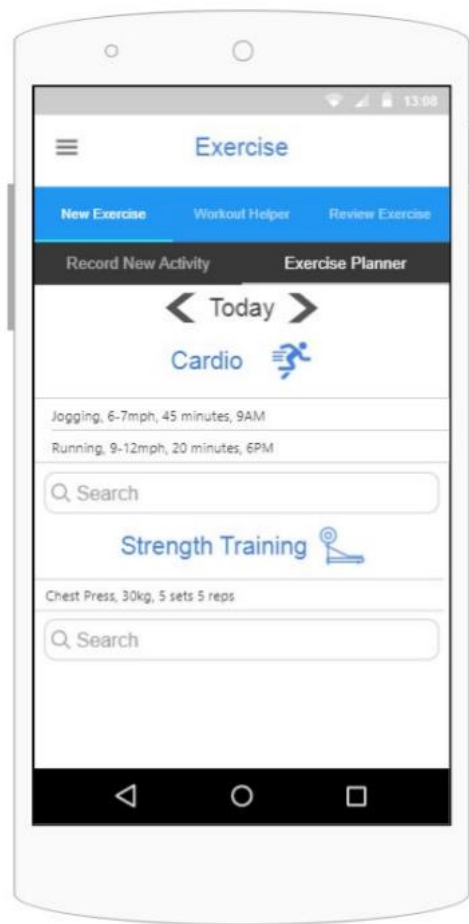
This is the screen that the user automatically loads when opening the exercise section of the app. From here the user can quickly input a new exercise in a couple of different ways. The page is broken up into cardio and strength, providing a database of exercises for each, as well as a frequent exercise list. If the user uses an exercise often or wishes to favourite one, it will appear in this 'frequent' list. If the user wants to do one of their frequent activities, they simply have to click play or plus next to it and the app will record the activity. Alternatively, if they wish to try a new exercise or something they do less frequently, they can search the database and input the exercise through that method as well.





- **The exercise planner**

The exercise planner within our app allows the user to plan an exercise for a future date. This is broken up into cardio and strength. Cardio type plans can include running at a certain tempo or cycling at a certain speed or for a certain distance or time. Strength planning allows you to fully plan a workout for that day, which you can tick off as you complete each exercise.

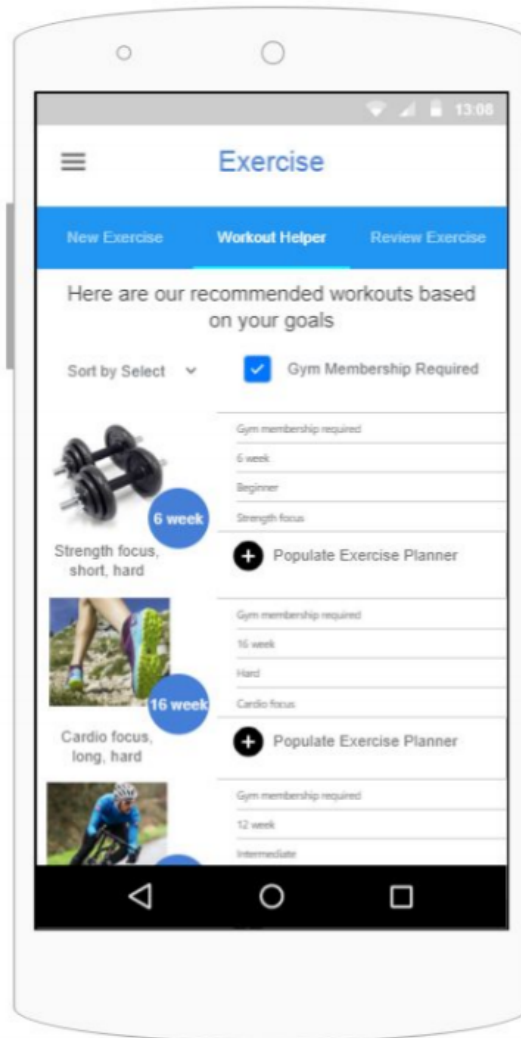


The exercise planner allows the user to plan exercise for subsequent days, as well as review what exercise they planned to do on previous days

The exercise planner lets the user plan what they're going to do ahead of time, allowing them to plan around their exercise or make sure they fit their exercise into a time when they're likely able to do it

- **The workout helper**

The workout helper provides detailed information on a variety of different exercises. It will not only explain good technique, but also provide a larger set of workouts designed by professional trainers. These workouts can be loaded into the user's planner. The app will be able to understand a baseline level of fitness from previous workouts and adjust the planned program to make sure it is achievable and safe. If a program is deemed too difficult for the user by the app, it will warn the user and suggest a different option that are more suitable. Possible programs can be filtered according to the user's situation e.g. having a gym membership.



The workout helper provides a list of long-term exercise plans tailored to the user's goals. The user can filter by gym membership requirement, as well as order by length, difficulty and focus (cardio/strength building) to supplement the goal-tailored results

If the user chooses to "populate" their exercise planner with the plan, it will automatically choose times for workouts that the user has historically exercised at, then ask the user for confirmation, at which point the user can edit the times before the exercise planner is populated. The user can edit times in the exercise planner at any time, though as the exercise planner serves as a guide for what the user should do in a day the time isn't essential.

○ The review screen

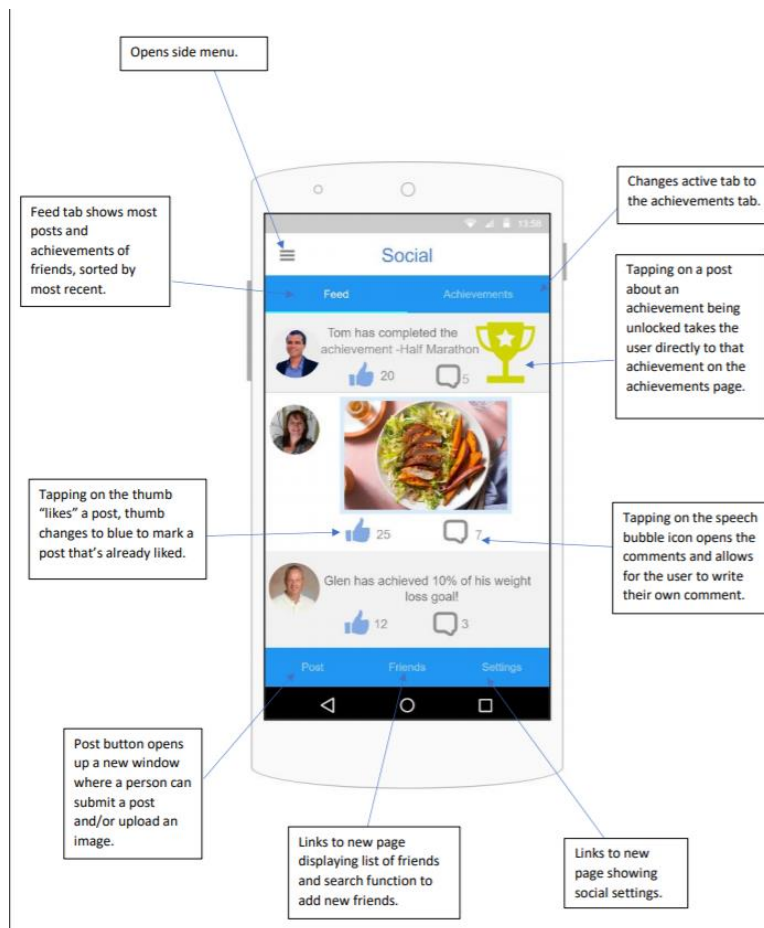
The review screen allows a user to view past exercises. They will be displayed in a list ordered by date of completion. Each item will show the key details from each exercising session, outlining the time, speed and calories burnt where appropriate. Clicking on an exercise will expand it showing all the gathered data on the corresponding exercise. This will also include any achievements completed during that exercise. The review screen will allow the user to edit any errors in the exercise data.

e. Social features of the app

The social features of the application are implemented to a much higher level to what we had previously considered. The user has the ability to share their achievements, interact with other users online, follow professionals and connect with other people to form a ‘friends’ group. The community feel around the application aims to increase the user’s engagement and motivate them to change their behaviour. The page is accessed from the home or side navigation bar. The screens that the user can access are as follows:

○ The Feed

This is the main screen, which allows a user to see what their friends have been up to and interact with others’ posts. Users will be able to follow accredited professional accounts on health and exercise for tips and recommendations but will not be allowed to comment. From the feed, a user will also be able to post a photo, achievement or exercise.



- **The Achievements page**

The achievements page shows all of the achievements available in the app. All completed achievements will be outlined in gold and a cup will be displayed in its top corner. Additionally every achievement will inform the user how many of their friends have completed the specific achievement. Each achievement can be shared on the social page. This example demonstrates one completed achievement - '*Gym Lover*', and some of the other incomplete achievements below. The screen also shows information on how many of the user's friends have completed the respective achievement.

- **The Friends page**

The friends page provides the list of the user's friends and a search bar to allow a user to find and add friends.

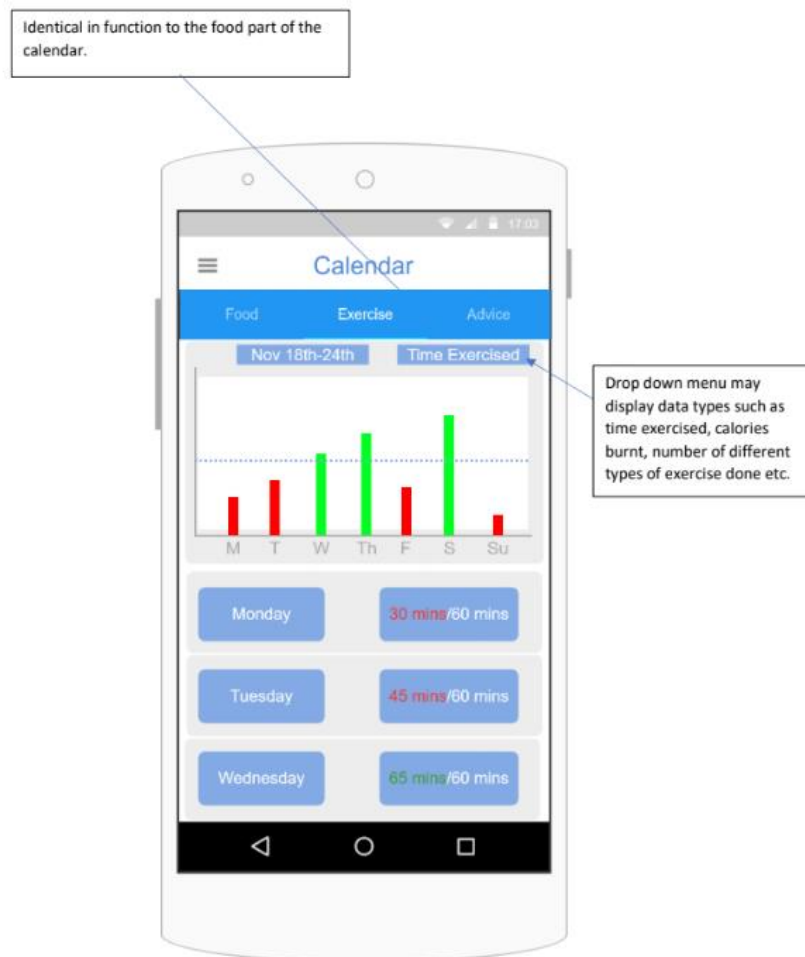
- **The Settings**

The settings button in the bottom left is a direct link to the profile settings page in the profile section of the app. There the user will be able to adjust all social aspects of their profile.

f. The general overview of user progress

This section of the prototype will provide the user with information about trends in their behaviour, aiming to prevent unhealthy tendencies. The interface is designed to present the user's progress using visual aids, while keeping the interface simple and accessible in the form of a bar chart or a calendar (for the weekly and monthly view respectively). The calendar presents information about the user's nutrition and exercise in a weekly or monthly view in addition to the daily view presented in the respectively the Nutrition, Exercise and Profile sections. The example below shows the weekly view. A monthly view is accessed by swiping the chart to the left, which would present the user with a colour coded calendar, through which they can examine trends in their behaviour in the long term and track their progress.

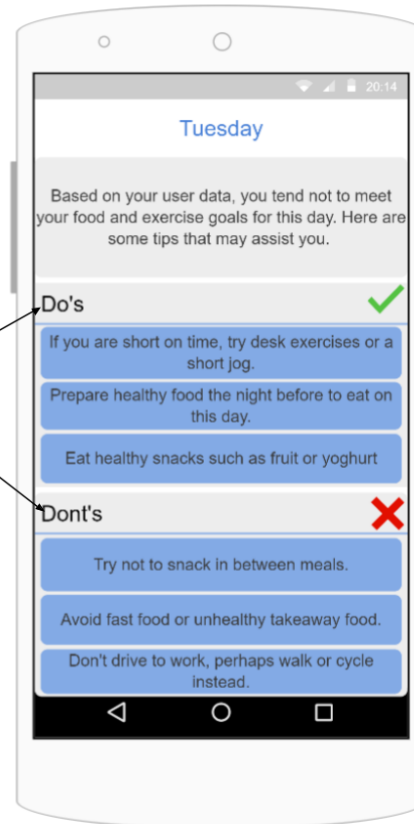




This section is accessible via the home screen by default. Furthermore, the specific information about the user's intake is also accessible from the Nutrition section and the information about the exercise section - from the exercise section respectively.

When accessing the 'Advice' screen the user will be provided with useful messages in a friendly tone (similar to the notifications' examples listed below) that highlight positive and negative trends in their behaviour, in order to reinforce healthy behaviour. If the user is still new to the app and the data is not sufficient the following message will be displayed: 'There is currently not enough information available for this feature. Please continue using this app and come back later.'

This page takes data from several other pages of the app, including the calendar, user goals and food and exercise inputs to tailor personalised advice for each user on how to improve their health on each day. It determines on which days a user tends to be unhealthy and offers preemptive advice on how to make that day healthier.



g. Notifications:

As briefly mentioned earlier, we were keen to implement notifications into this generation of the app. Notifications serve multiple purposes but importantly they encourage frequent engagement with the app and prevent a user from forgetting about their goals. Our studies highlighted that users of health apps appreciated being provided with progress updates and actionable recommendations; we believe that these recommendations work well through notifications. The purposes for notifications along with specific examples are outlined below.

Notification type	Description	User interaction	Example
Automated exercise	A notification will appear when an exercise has been automatically detected.	There will be a cross to cancel the automated exercise from the notification	‘Automatic exercise being logged: Jog on! It appears that you are running’
Exercise in progress	A notification will be displayed whenever the user has started an exercise through the app.	The notification allows the user to end their exercise from the phone lock screen.	‘Cycle ride in progress, click here to end exercise’
Reminders to input food and exercise	A notification will be pushed if the user has not inputted data for their breakfast by midday. The same applies for lunch and dinner at their respective times.	Clicking the notification launches the app and takes them to the food input screen.	‘You must be hungry! You haven’t entered your breakfast. Please click here to add it now.’
Low activity reminder	A notification will be pushed if the user has been inactive for several days.	N/A	‘Where have you gone!? We have missed you!’
Social reminders	Notifications to inform users that a friend has posted to their social feed	Clicking opens up the users feed and takes them to their friends activity	‘James has a new achievement! Click here to see more.’
Social reminders	Another social reminder could be implemented if someone challenges the user	Clicking opens up the challenge and allows the user to accept or decline	‘Bring it on! James has challenged you.’
Planner reminders	Notifications to remind users that they have a planned exercise in 1 hr	N/A	‘Exercise time soon! You have a planned work out in an hour.’

Goal progress	Notifications could be pushed if the user has reached their daily step goal or achieved half of their overall weight goal	N/A	‘Keep it up! – You have just reached your step goal for the day!’
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Importantly the number of notifications will be adjustable in the setting menu to prevent a user from getting overloaded by the quantity.

h. Wizard

We recognise that users of mHealth applications often struggle with understanding the application’s features and navigating their way around. We realise that some of the features we are implementing might not be intuitive (e.g. customising home screen). In order to ensure that the users of our system are not left confused, our app ensures that when a user opens the application for the first time, they are greeted by a ‘helpful wizard.’ If the user is experienced with other mHealth/weight management applications, they will have the option not to interact with the wizard.

The wizard functions as a tutorial for the user. It explains how the system functions, what features the user can take advantage of and how they can navigate around the system. The wizard encourages the user to take a look at all the different parts of the system and provides them with additional information about certain elements that might not yet be available (e.g. recommendations in the ‘*Calendar*’ will not be available at the very beginning). The wizard encourages the user to utilise all the functionalities of the system, but does also highlight how some elements can be customised.

5.4. Evaluation of the prototype

Methodology

For the second generation prototype we elected the same methodology as for the evaluation of the first to allow for a comparison with previous prototypes, in order to highlight areas of improvement. As a reminder, the scoring system works based on 6 points (from 0 to 5) with values of 0-1 indicating that a heuristic was fulfilled poorly or not at all, 2-3 indicating that a heuristic was fulfilled somewhat and 4-5 indicating that a heuristic was filled very well or entirely. We choose three evaluators to assess each prototype individually and assign a value for each of the selected heuristics within the scoring system defined above.

This average for each heuristic was compared to the average score of the first generation prototypes for that heuristic in order to highlight areas of improvement, or else areas where improvement could have been greater.

Second Generation Prototype:

Heuristic	Evaluator 1	Evaluator 2	Evaluator 3	Average
Visibility of system status	5	5	5	5
User control and freedom	4	5	3	4
Consistency and standards	4	4	3	3.67
Recognition rather than recall	4	4	4	4
Flexibility and efficiency of use	5	4	3	4

Aesthetic and minimalist design	4	5	4	4.33
Match between system and real world	3	3	3	3
Error prevention	4	5	3	4

Total Score = 32/40

- **Visibility of system status**

User inputs result in live (immediate) and local (on the same interface) changes indicating status update. Using search bars opens search results, inputting exercise and food automatically shifts calorie surplus/deficit calculations and the exercise interface shows clearly whether or not it is currently recording a frequent workout with the play/pause button and live timer. The result of this is a high level of user understanding of the system while it is being used.

- **User control and freedom:**

The user is arguably constrained by the splitting of meals. However, the literature review shows that splitting meals is desirable as it establishes regular eating times, especially in conjunction with the automatic notifications half an hour before set meal times. The user also has a wide range of choice for inputting meals, such as adding individual food items, scanning barcodes or adding recipes from the database or their saved recipes. Similarly, they can search for a wide range of exercises manually as well as having the option to confirm automatic workouts; this endows the user with a great deal of control while not compromising on ease of use.

- **Consistency and standards:**

Common attributes to all interfaces are kept consistent throughout. Consistent icons are used across the interfaces. For example, the black and white cross for adding exercise is the same as the icon for adding food, and the heart for favouring recipes is the same on all recipe tabs.

- **Recognition rather than recall**

The provision of ‘frequently’ and ‘recently’ shortcuts on the exercise and food interfaces remind the user of some likely inputs they need to make, providing a cognitive leap.

Additionally, the automatic workout recording interface removes the need for the user to recall these figures like duration of the exercise, as the information is already presented to them.

Relying on recognition rather than recall improves usability and by making the system easy-to-use encourages a user to continue using the application.

- **Flexibility and efficiency of use:**

The app features a great deal of customisation. The home screen can be personalised with a variety of different shortcuts and widgets. The inputting of food and exercise is highly flexible, with both a manual and automated system being available. The exercise section allows for a start/stop timer of the exercise, and the food section features a barcode scanner. Both of those cater to users who prefer the convenience of an automatic input. The efficiency of the app is improved by personalised advice, tailored to each individual user. The ‘advice’ screen on the calendar offers recommendations based on previous inputs to identify key areas and days when the user should focus on to improve their general health. Efficiency is also drastically improved by the personalised recipe book, sparing the user the need to manually input whole meals or to search for recipes they’re likely to use multiple times. Similarly efficient features are the ‘frequent’ and ‘recent’ options for adding exercise and food the user is likely to input multiple times.

- **Aesthetic and minimalist design**

The design has a clear focus on colourful images, which draw the attention of the user to important elements (such as the recipe interfaces). A simple but consistent colour scheme (blue, white and grey) is kept across all interfaces, broken only to highlight important features. The

calendar has its own internal colour scheme on the graphs for exercise in active minutes and calorie intake, represented daily against a user's individual target on bar charts with the bars coloured red, orange or green depending on how well the user met their targets on a particular day. This is a simple and effective way of representing data in an understandable manner.

- **Error prevention**

The app has a number of fail-safes inbuilt to prevent users from inputting incorrect values through drop down menus and fixed input options. Users are presented with the option to accept or decline automatic inputs on the exercise screen, as well as the ability to edit all input.

5.5. Comparative Analysis: First Generation Prototypes to Second Generation Prototype

	Generation 1	Generation 2	Improvement
Visibility of system status	2.44	5	+2.56
User control and freedom	1.89	4	+2.11
Consistency and standards	0.89	3.67	+2.78
Recognition rather than recall	2	4	+2
Flexibility and efficiency of use	2.33	4	+1.67
Aesthetic and minimalist design	1.67	4.33	+2.66
Match between system and real world	1.11	3	+1.89
Error prevention	2.11	4	+1.89

The improvements between the First and Second Generation Prototype are significant, with the average scores for each heuristic going up by around 2 points, sufficient to raise each heuristic's performance by an entire category. The most significant changes were in consistency and standards and aesthetic and minimalist design, some of the worst performing heuristics in the first generation prototypes. The improvement here is due to the change in software used to design the prototypes and creating a fixed library of assets that can be reused across several interfaces to create an appearance of consistency. The consistency between screens was also improved through the addition of the 'road map' displaying the overall layout of the interactions between the individual screens. The side-bar menu also helps for maintaining consistency between screens as it is always accessible and remains unchanged regardless of where it is accessed from. The side bar menu also increases the efficiency as it allows for quick and easy navigation between key screens. Visibility of system status also saw a large increase in score, due to the improvements in coordination between different screens and different processes recording and displaying more detailed data to the user.

5.6. Recommendations for future prototypes:

By studying the score for each heuristic, we can extract a set of recommendations for future prototypes. The heuristics which need little to no work are:

Visibility of the system status: Providing future prototypes don't compromise on the current 'live and local' system status updates, there need be no improvement to features affecting this heuristic alone

User control and freedom: The user faces some constraints but only those that are logical and work overall to the benefit of the user. If an 'override' could be implemented so as a really determined user wouldn't be constrained by the 3-meal-a-day regimen imposed by the meal tracker then this would potentially be an improvement, but this is non-essential.

Aesthetic and minimalist design: The design is generally very aesthetically pleasing and minimises clutter while maximising feature inclusion. The methods the prototype uses to achieve this in its most successful interfaces (such as splitting up a complex interface with tabs in

order to create easily navigable and less busy sub-interfaces) could be easily expanded into some of the more cluttered interfaces to tidy them up.

Heuristics which would benefit the most from improvement are:

Consistency and standards: There is some enduring inconsistency between interfaces, which is concentrated mainly on interfaces other than the food and exercise interfaces (which largely mirror each other). This is a shortcoming in the 2nd generation which would be easy to tidy up in future prototypes by ensuring that assets are properly shared and uniform between all interfaces and not just the main ones.

Match between system and the real world: There is still a disconnect between real-world examples for things such as exercise planners and our interfaces, despite the meal planner being very similar to real world ones available from in-person weight loss programs. This is highly actionable, with real-world equivalents for many features being easily adaptable into technological features, which could be incorporated into the interfaces for a future prototype.

06. Summary

Over the course of this project we significantly improved our knowledge of how persuasive technologies can influence people's behaviour. In order to integrate features that encourage long term changes to people's eating habits and behaviour regarding the integration of regular exercise we researched different areas and approaches to weight loss. We also took a close look at how mHealth applications in general use (or fail to use) certain behavioural change techniques. Following from our research, we closely investigated existing software that encouraged a change of user behaviour in various different ways – focusing on a point system and integrated support system (Weight Watchers), focusing explicitly on either exercise (Endomondo) or on nutrition (LifeSum). Taking into consideration the goal of our project (creating an application that is focused on increasing the user's awareness of their health, while catering to all kind of health conscious users) we examined the most popular weight management application on the market, which successfully caters to a wide variety of users (MyFitnessPal) and one of the most credible sources of information regarding improving the overall health of the user (NHS Weight Loss).

In order to understand the users of our system, we composed three different personas, whose aims and scenarios introduced different challenges when composing a mobile application suitable for people from various backgrounds with different levels of knowledge regarding health, nutrition and exercise patterns. Using the requirements of our personas and our personal experiences, we constructed three low fidelity prototypes. Each prototype aimed to cater to a variety of users with slight changes between the different interfaces and the way in which features were integrated. All prototypes maintained the same overall structure and focused on making the system accessible, while introducing a variety of features to suit each type of user we were imagining.

During the time we spent working on this project, we face a couple of major issues. One of the main issues was the lack of clear focus of how the design of the system would persuade, educate and engage the user base. From the very beginning of the project, we were conscious of the fact that mobile applications that aim to change a user's eating and exercising habits are popular across different demographics. While we were considering how to make our system

suitable for a variety of users (from people with little knowledge about dieting, to people who want to focus solely on creating healthy habits and maintaining their weight to people who want to build muscle mass or gain a healthy amount of weight), we did not carefully consider the purpose of each prototype as a singular system. In aiming to cater for a large audience, we created very similar prototypes that were partially inspired by our research and partially by the personas and scenarios we created. During the evaluation of the first generation prototypes, it became apparent that while we had explored different ways in which each feature can be implemented, we were not successful in producing a convincing, easy-to-use and consistent prototype. These problems encouraged us to revisit our previous work and focus on creating a clear underlying structure for our second generation prototype.

Another major issue we faced in executing this project was our focus on completing different elements of a task, as opposed to considering the project as a whole. Perhaps, due to the lack of communication between us, some of the different sections we were working on did not follow the same composition (e.g. the reviews of existing mobile applications had varying amounts of information provided and loosely followed the framework). This issue led to us revisiting multiple sections of the project, while simultaneously working on the next one. The lack of full and complete previous sections not only increased our overall workload in the later weeks of the project, but also introduced inconsistencies. This became especially apparent when we revisited the literature review before constructing the second generation prototype and discovered that many of our findings and conclusions had not been fully utilised in the first generation prototypes.

When constructing the second generation high fidelity prototype, we dedicated the majority of our time understanding the underlying navigation system, the structure and overall aims of our system. While not all the features we discussed were included in the final version of our prototype, we created a much better prototype, which had a clear focus on encouraging the user to change their behaviour in order to improve their overall health. The prototype also utilises a lot of the behavioural change techniques, the postulates of persuasive design, as well as features of mHealth applications users have highlighted as motivating in our review of related work.

Overall, this project has helped us to not only better understand the theory behind behavioural change in regards to weight maintenance and encouraging healthy behaviour, but also the challenges of creating software systems, which build upon existing research while catering to the needs of their users. Although we have struggled to find the balance between design, functionality and usability, we are more confident in our ability to construct a fully functional system. If we were to undertake a similar project in the future, we believe that having clear aims at the very beginning, accompanied by careful planning and consistent communication between the team would be extremely beneficial. Additionally, we realise that undertaking research and understanding our users is something we didn't focus on enough in our project and would be more conscious of that in the future.

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