Mobile Applications to Support Dietary Change: Highlighting the Importance of Evaluation Context

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Abstract
Along with the smart phone came smart phone applications, which range in functionality, complexity and price. Hugely popular are lifestyle applications which include tools for diet and exercise. Despite the popularity of these applications however, we have yet to see any form of rigorous investigation into their value, i.e. their impact on user behaviour and long term health goals. We embarked on a live clinical trial of a behavior based mobile application designed to assist users on meal replacement diet programs to judge its impact and value. Our analysis showed that users were more engaged with a fully interactive application than an information based application, and that varying analysis conditions seemed to result in varying impact.

Keywords
diet; health; usage; intervention; application; mobile

ACM Classification Keywords
H.5.2 [**Information Interfaces and Presentation**]: Miscellaneous

General Terms
Design, Human Factors, Experimentation.

Figure 1: task notification; dashboard

Figure 2: weight loss visualisation; textual feedback for users

Introduction

Smartphones and Internet-enabled mobile phones have overtaken the mobile market USA[2]. The availability of mobile Internet connectivity offers innovative and far-reaching means for the delivery of intelligent information services, particularly in the health domain. One of emerging areas for mobile health (mHealth) applications is lifestyle and obesity. The number of obese and overweight individuals has been steadily increasing world-wide [1], which has brought to the fore the need for mHealth applications that help individuals to maintain active lifestyles and stick to healthy diets. Evidence based and scientifically evaluated mHealth applications can offer convenient, intelligent, and easily accessible means to support dietary intake recording and ongoing behavioural change support [5].

While the popularity of mHealth applications amongst smartphone users has soared, recent research identified the shortage of evidence based applications and research related to the long and short term effects of application usage [3]. We have developed a novel behaviour based mHealth application, Weight Management Mentor (WMM) which aims to support users on diet and behaviour modification programs, and promote self regulation and reflection. WMM is implemented as an interactive iPhone application that collects food intake and weight data and increases user awareness through its graphical and textual feedback mechanisms. In addition to allowing users to record their food intake and weight data, WMM highlights the users' progress towards the desired goals through various visualisations, virtual rewards, and motivating feedback. A key novelty of WMM is that it proactively prompts and reminds users to interact with the application several times daily by initiating health- and self monitoring-related tasks, and increases user engagement through tailored textual messages of support and praise. In this work we report on a clinical trial of WMM aimed at judging its impact and role in supporting individuals.

As researchers we are keenly aware that our experimental analysis should align with, if not fully replicate real world scenarios in which our product will be used, in order for real world impacts to be fully understood [6, 7]. The understanding that context is key mainly aims to guide researchers in decisions involving the type of trial and also participant recruitment. Our analysis, as well as informing our knowledge of the applications impact, suggests that on a more fine grained level the context of the evaluation scenario and the provision of resources which can assist users in achieving their goals can influence the impact of the tool or technology being trialled and highlight the need for careful consideration of experimental results drawn from live user studies. Results show that during a clinical trial our mobile application appears to have impacted on the weight loss of participants differently when the products required for the diet were supplied versus when participants were required to purchase their own products. This knowledge both suggests that researchers carefully consider their results, both positive and negative, in the context in which they were obtained and also highlights the different roles which assisting technologies can play in intervention programs of varying structure.

Weight Management Mentor

The Weight Management Mentor application aims to support participants of the meal replacement intervention program Celebrity Slim[1] by providing information, simplifying food intake recording, rewarding positive behaviour, and prompting regular interaction through reminders [4]. A key feature of WMM is that it reminds

[1] www.celebrityslim.com.au

Figure 3: meal reporting screen; monthly calendar with stars

Figure 4: summary of daily meals; meal graph summarising last five days

Figure 5: trophy room; new trophy achieved

users to interact with the application at appropriate times through pop-up notifications that appear at the smartphone's desktop (Figure 1 left). WMM sends notifications of assigned tasks to users three times daily, corresponding to typical meal times. The tasks center on weight measurement and food intake recording and are relevant to the time of day and defined user routines. The WMM dashboard allows users to interact with the offered features: My Meals, My Weight, My Tasks, Trophies, Information, and Settings (Figure 1 right). The dashboard also contains a message board that shows greetings, motivational messages and thoughts for reflection on diet progress.

To complete assigned tasks, users select the My Tasks dashboard icon and are presented with a task list that contains the tasks assigned for that day and overdue tasks (from previous days), if they exist. Each morning, users are requested to record their weight through a direct question or the My Weight screen. WMM communicates weight loss progress to users (Figure 2 left). Each week users receive tailored motivational feedback messages, which reflect their current progress. The aim of the feedback is to encourage dieters to continue their participation on the diet, increase their interactions with WMM, highlight the importance of self-monitoring food intake and weight, and provide additional tips and relevant information (Figure 2 right).

Users are prompted to record their food intake three times a day. The morning task prompts users to reflect on the previous day, and complete and confirm the food intake. Around lunch time users are asked to start the food recording for that day, and in the evening they are asked to complete this recording. Food intake recording is achieved through a simple drag and drop interface, which can also be invoked by selecting the My Meals icon. According to the Celebrity Slim meal replacement program (MRP), food intake focuses on recording meal replacements, balanced meals, other meals, allowed snacks, and other snacks, as shown in the colour coded palette (Figure 3 left). Users select meals and snacks from the palette and drop them into the appropriate time of day spanning from waking to bedtime, which represents their food intake by coloured dots. Dietary intake for previous days could be viewed by scrolling through the calendar using the arrows at the bottom of the screen. Daily compliance with the MRP guidelines is communicated to users by a visual cue at the bottom of the screen. A gold, silver or bronze star reflects how well the daily food intake meets the guidelines. A gold star means that the guidelines were met, silver that intake was close to the guidelines, and a bronze means that some progress towards the guidelines was made. A calendar showing the stars for each day is also accessible (Figure 3 right), as well as textual and chart based feedback on each food type, (Figure 4 left and right).

To further motivate regular interaction with WMM, users are awarded virtual ribbons and trophies for completing tasks, recording food intake and weight, and in general using WMM to engage with the diet. Each user has a trophy room, which can be accessed by selecting the My Trophies dashboard icon. This shows the trophies already achieved and communicates the progress towards the next trophy (Figure 5 left). Once a new trophy is earned, an appropriate motivational explanation is shown and the trophy is added to the trophy room (Figure 5 right). Dietary information presented in WMM is extracted from the Celebrity Slim website and includes information on the MRP, recipe ideas, nutritional facts for the meal replacements, and answers to frequently asked questions

about the MRP. This can be accessed at any time by selecting the Information dashboard icon. Also, brief tutorials on the WMM's interactive features are included. Finally users can configure the task delivery times by selecting the Settings icon.

Live Evaluation

We conducted a user study aimed at evaluating the effectiveness of the WMM prototype for the MRP participants and its impact on user engagement with the diet and weight loss. The overall aim of the study is to investigate the effectiveness of an automated mobile phone based diet and lifestyle, prototype support tool, Weight Management Mentor, to increase consumer retention and weight loss on meal replacement programs (MRP). The primary outcomes for this study are retention on the MRP and weight loss. 56 female participants with Body Mass Index (BMI) of 25 kg/m2 or above were recruited and participated in the eight-week clinical study. The study period was split into 3 distinct phases. The study intervention period was made up of the first 6 weeks of the study, the remaining 2 weeks were follow up. The intervention period had two distinct sub-phases,a 4 week supported intervention period, where participants received meal replacement products for free, and a 2 week independent intervention where participants were expected to purchase their own meal replacement products.

As the study was a clinical trial participants were required to visit the clinic on 5 occasions over the 8 week duration. On *Visit 1* (Week 0, Baseline) participants provided consent, had the application installed on their phone, had their height and weight measured and collected their meal replacements for the first 2 weeks of the study. *Visit 2* (Week 2) saw participants once again have their height and weight measured, they collected their meal replacements for the following 2 weeks and completed a study questionnaire. At Visits 3 (Week 4), *Visit 4*(Week 6, end of intervention) and *Visit 5*(Week 8, follow up) participants had their final height and weight measurements taken. Thus the study gathered detailed user feedback on the application as well as usage information through interaction logs and importantly real rather than self reported weight measurements.

Participants were randomly assigned to two groups. 30 participants (7 withdrew over the course of the study) were assigned to the baseline group and provided with the baseline WMM application that included only the information about the Celebrity Slim MRP and had no interactive features or prompting. The baseline WMM application imitated the offline MRP scenario, where participants could access diet information, but could not benefit from any support features. 28 participants (7 withdrew) were randomly assigned to the intervention group and provided with the interactive WMM application as described earlier. All user interactions with WMM were logged, participants completed pre- and post-study questionnaires, and were interviewed at four- and eight-week checkpoints. The key question under investigation was the engagement of users with WMM and the resulting weight loss. Engagement with WMM was quantified by the number of days that users interacted with WMM and the number of activities performed by users, such as activating WMM, responding to tasks, updating weight measurements, adding/removing meals, from the meal diary, and accessing the MRP information. Given the difference in functionality of the two versions of WMM it is natural to expect a large variation in application usage between the two evaluation groups as illustrated by the usage summary in Table 1.

group	active days	user activities	info accesses	weight loss recorded
baseline	10.08	100	1.24	??(82.6%)
intervention	42.81	2120.05	11.69	??(94.7%)

Table 1: User interaction with WMM

The interactive version of WMM clearly engaged the users more than the baseline: users interacted with the interactive version on more days and the amount of interaction was substantially higher. The only direct comparison that can be made is to compare the uptake of the average number of times a user accessed the MRP diet information and we see that users with the interactive WMM visited the MRP information almost 10 times more than those with the baseline application. A key measurable from the study is weight loss. We hypothesised that users with the interactive WMM, those who received prompts and who could self monitor and record would lose more weight than their counterparts who simply had access to information. We note in the rightmost column in Table 1 that the majority of participants recorded an overall weight loss when compared to their initial weight. We do note that more participants (94.7%) in the intervention group successfully lost and maintained weight loss over the 8 weeks than those in the baseline group (82.6%).

To gain further insight into the observed weight loss we examined each phase of the 8 week study (Supported intervention, independent intervention and follow up) in terms of weight loss separately. In the supported intervention period a similar proportion of dieters in the baseline (95.7%) and intervention group (95.2%) users recorded a decrease in weight, such that relative weight loss - percentage of the weight recorded at the beginning of the study - ranged 0.4% - 4.34% in the control group from 0.5 - 5.6% in the intervention group with a mean percentage weight loss at week 4 of 2.39% in the baseline group and 2.99% in the intervention group as illustrated in Figure 6.

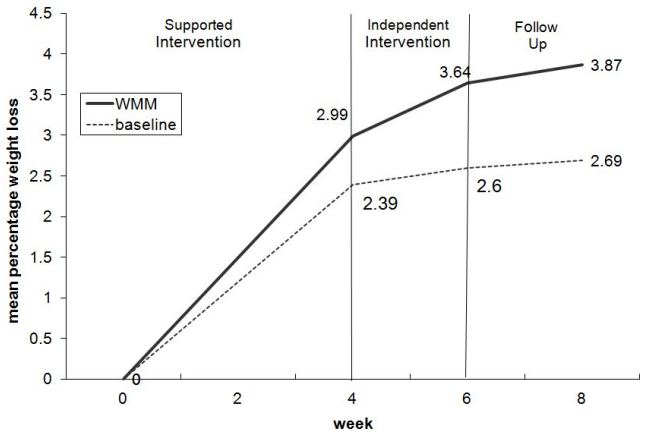

Figure 6: Percentage Weight loss

During the independent phase of the intervention we note that the trend in mean weight loss changes. Neither condition manage to sustain the rate of weight loss seen in the supported intervention period but those using the interactive application achieve a much higher rate of loss in the independent intervention period (0.65%) in comparison to the baseline group (0.21%). This trend continues in the follow up/maintainance period where those in the intervention group lost an another 0.2% while those using the baseline app lost less than 0.1%.

Discussion

It seems our application had varying impact on dieters in different dieting contexts. We note that the fully

functional app appears to support dieters throughout the study with apparent higher weight loss achieved. At the completion of the supportive intervention period the intervention group had a 25% more weight loss than their baseline counterparts. However, when dieters were no longer supplied with the meal replacement products the increase in mean percentage loss increases to 40% and even to 43% by the end of the study period. Thus the application seems to have had increased impact when dieters were purchasing their own meal replacement products. This could be due to the convenience of having the products provided, or the costs saved through provision. We hypothesize that had we reduced or removed the period of supported intervention in this study we could have seen even greater weight loss figures in our study. It may also be the case that the application has more impact in the later stages of the dieting period when support is more sought after by dieters. Further analysis and further studies are required to determine the exact cause of the applications performance.

The impact of this finding is two fold. Firstly, it highlights the need to perform true live user studies in order to obtain true to life performance of mobile applications. Secondly, it highlights the varying roles that technologies of this type can plan in varying intervention programs. Mobile applications of this form may be very supportive in intervention programs which require high user involvement, planning and independent monitoring, such as Weight Watchers [2], but play lesser role in interventions where meals or products are provided to users either for free or for a fee such as Jenny Craig [3].

[2] www.weightwatchers.com
[3] www.jennycraig.com

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