EFFECTS OF PRESCRIPTIVE DESIGN ON THE USAGE OF A WALKING APP

A Thesis

Presented to

the Faculty of the Department of Computer Science

University of Houston

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

By

Ashik Khatri

May 2015

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Abstract

Walking is the most ubiquitous physical activity. Natural walking opportunities, however, have been declining in developed societies. This decline has been linked to the rise of obesity. iPhone and Android health and fitness apps aim to reverse this trend by motivating people to be more physically active. The core philosophy in many of these applications is to overwhelm the user with information and promote user competition.

In this thesis, we present a walking app design that is antithetical to the main trends. This new design is based on minimalism, where targets are set in a prescriptive manner and competition takes a secondary role. Specifically, the app gives to the user a daily caloric goal to consume by walking. The formula that computes this goal is based on the users food intake, Basal Metabolic Rate (BMR), and Body Mass Index (BMI). Our hypothesis is that authoritative directions conveyed with single-minded simplicity have better chance than prevailing methods to keep the user engaged. Results from a comparative study render support to this hypothesis.

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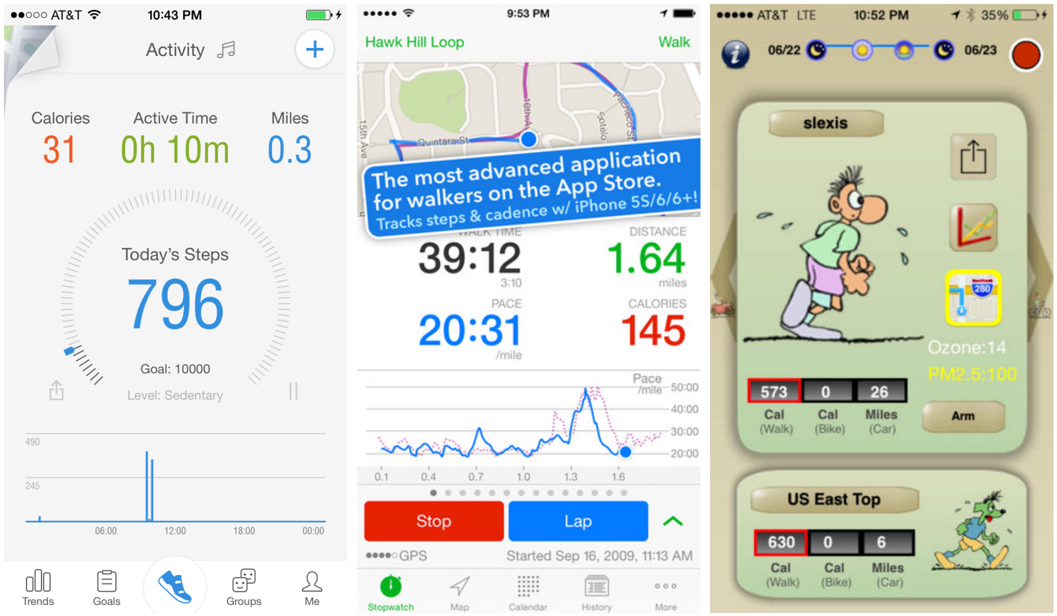
Chapter 1

Introduction

The sedentary lifestyle is a serious problem in modern societies. According to the U.S. Department of Health and Human Services (DHHS), only 33% of adults engage in physical activity on a regular basis in the United States [14]. Long-term inactivity is associated with the emergence of the obesity epidemic and significant morbidity [3]. Due to this, several mobile applications aim to motivate people to be more active. Some highly rated apps on the iTunes Appstore are Pacer [Fig. 1.1a], Walkmeter [Fig. 1.1b], and our own app iBurnCalorie [Fig. 1.1c].

However, there are some drawbacks in each of these apps. The Pacer app by default gives every user a goal of 10,000 steps. This is not only an arbitrary goal but also misleading. Two people of the same height, but one weighing 150 lbs. and the other 250 lbs., will need to walk a different number of steps to burn the same number of calories.



(a) Pacer (b) Walkmeter (c) Old iBurnCalorie

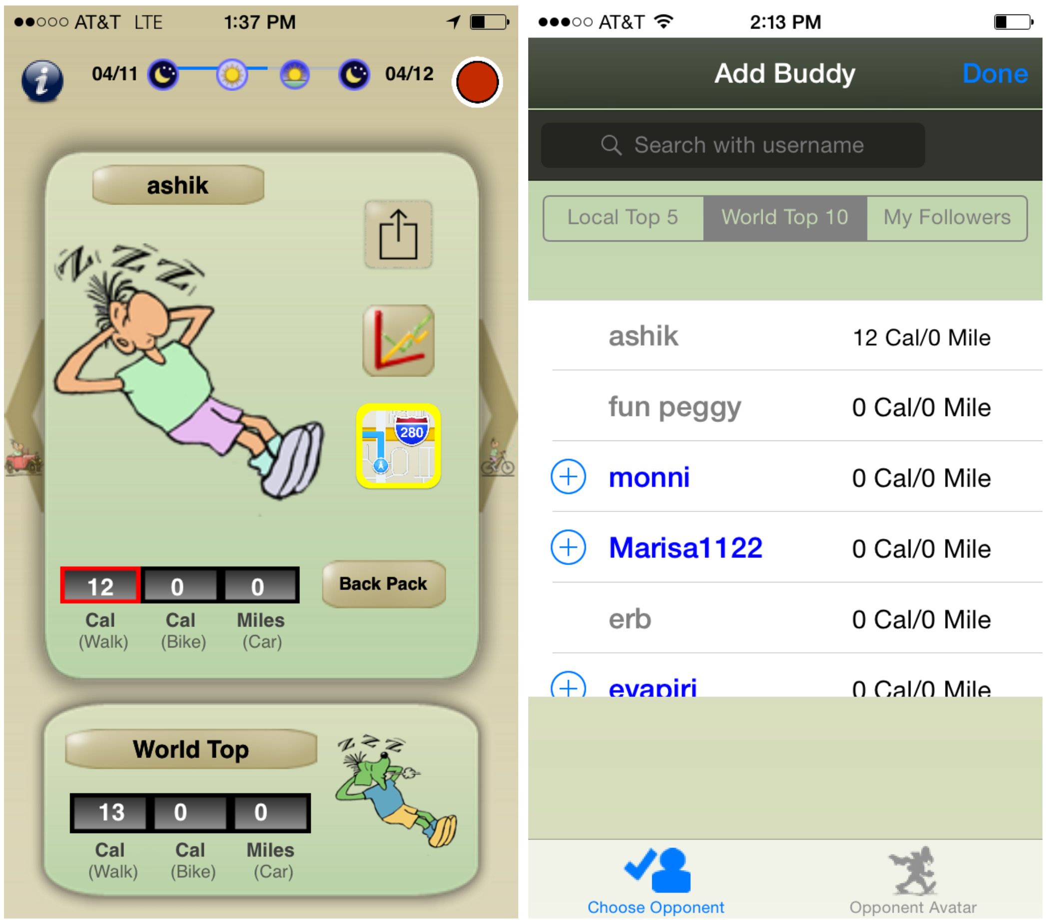
Figure 1.1: Smart Health - Walking Apps. This figure shows screenshots of Pacer, Walkmeter, and old iBurnCalorie apps.

The Walkmeter application [Fig. 1.1b] has an overloaded design. On its main screen, pace, time, calories, and distance are all equally highlighted; the home screen also features a map and a graph. Designing an aesthetically simple and pleasing application is vital to retain users. Users tend to quickly trust an application that is simple in design and aesthetically pleasing [9].

The old iBurnCalorie [Fig. 1.1c] tracks how many calories user burns via walking and biking. It uses calorie computations reported in Fujiki et al [4]. It also supports the additional informative feature of recording miles driven. iBurnCalorie also uniquely integrates man-made weather pollutant information, OzoneMap [16] [17] [10] [11] and ParticleMap. After the login and registration process, the user by default follows a virtual user called 'World Average', a statistic computed by the application. At the user's discretion, this virtual user can be replaced by other statistics like World Top [Fig. 1.2a], World Top 5, or another real user (a buddy) [see 'Add Buddy' in Fig. 1.2b]. At any time, the user of the application is allowed to compete head-to-head with another virtual or real user. The app is designed to promote one-to-one social competition. The goal of the user is to burn more calories than her/his opponent. However, a problem arises when the user is following someone who is not very active and burns fewer calories than s/he needs to burn for their metabolic balance. The user of the app may not remain motivated enough to be consistent. Also, there is no clear direction as to what the user of the app needs to do for her/his individual metabolic balance.

As we have seen so far, the current crop of smart health applications lack simplicity and optimized goal setting. Therefore, we set out to redesign our iBurnCalorie application based on simplicity and minimalism, focusing on meaningful and personalized health goal, and with social competition as a secondary motivator.

This thesis is organized to cover the redesign of iBurnCalorie, data collection and results in Chapter 2, and 3. In Appendix A we introduce the reusable iBurnCalorie framework.



(a) (b)

Figure 1.2: Old iBurnCalorie Screeshots. 1.2a shows the home screen of old iBurnCalorie and 1.2b shows the buddy selection screen of old iBurnCalorie.

Chapter 2

Design

2.1 App Design

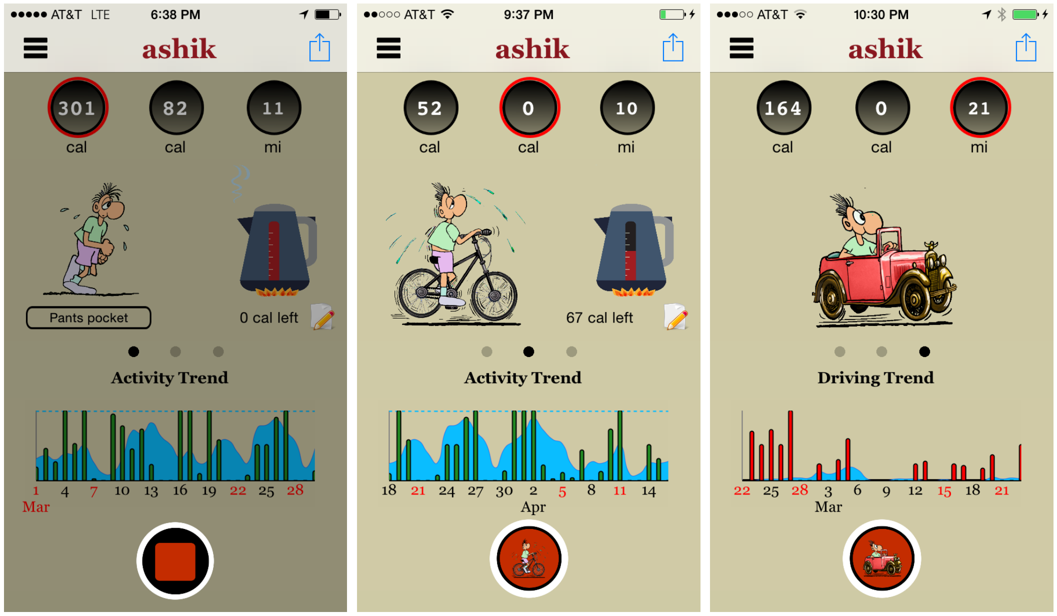
In the new version, we modified the one-to-one social competition concept of iBurnCalorie, in favor of a more traditional prescriptive approach. The hallmarks of the new design are:

- Personalized and meaningful health goal
  - Calories to burn for the day
- Social context
  - user activity vs. group activity
- Flat icons and hamburger menu
  - Consistent with iOS design principles

Since the first part of the redesign process was simplicity and minimalism, we describe how we achieved this in Section 2.1.1.

2.1.1 Achieving Simplicity

According to John Maeda, the simplest way to achieve simplicity is through thoughtful reduction. Maeda offers a concise method for working with this law called "SHE", which stands for "shrink, hide, and embody" [12]. We used this for our application redesign. We took a careful look at the old iBurnCalorie design [Fig. 1.2a]. We noticed that we did not need the timescale at the top of the application. Furthermore, the map and information buttons are not necessarily required on the home screen. The central focus of the application should be for the user to see how many calories s/he has burned. Lastly, the record button on the top right and the calories being reported needed to be emphasized. So after shuffling the user interface we transformed the app as shown in Figure 2.1. We also replaced one-on-one competition of the old design, with an Activity Trend graph as seen in Fig. 2.1a. Specifically, the app's default mode is the recording of walking activity [Fig. 2.1a]. The app can still record biking activity [Fig. 2.1b], and car mileage [Fig. 2.1c]. The latter has been introduced to inform users of a mobility mode they should best avoid, as it involves no physical activity.



(a) (b) (c)

Figure 2.1: New iBurnCalorie - Home Screens. 2.1a shows the walking mode, 2.1b shows the biking mode, and 2.1c shows the driving mode.

2.1.2 Goal-Based Approach

The ultimate goal of physical activity is for a person to maintain a healthy metabolic balance. The key measure to follow in this respect is the number of calories expended. All other measures (e.g., steps taken) are derivative measures, and thus partially redundant.

The most fundamental concern of a user should be if s/he burns enough calories each day in order to counter-balance the calories taken in through food. Any imbalance in this metabolic equation will result in weight gain. To this end, we allow the user to input the calories they eat daily [Fig. 2.2]. During registration [Fig. 2.3], the user is asked for their Age, Gender, Height, and Weight. After the registration the user is greeted with the goal screen [Fig. 2.2]. Once s/he inputs the number of calories s/he has eaten daily, we use Eq. 2.1 and Eq. 2.2 to compute how many calories are required to burn to maintain or reduce weight. The Basal Metabolic Rate (BMR) is calculated using Formulas 2.3 and 2.4. [13]

Figure 2.2: Goal Setting. On this screen, the user is allowed to set her/his daily caloric goal.

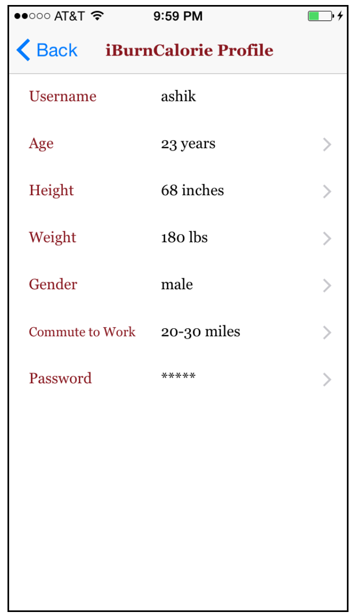


Figure 2.3: Registration Screen. Here the user sets her/his age, height, weight, and gender.

$$Calories_{maintain} = Calories_{intake} - (BMR + BMR * 0.1) \tag{2.1}$$

$$Calories_{weightloss} = Calories_{intake} - (BMR + BMR * 0.2) \tag{2.2}$$

$$BMR_{male} = 5 + (10 * weight_{kg}) + (6.25 * height_{cm}) - (5 * age) \tag{2.3}$$

$$BMR_{female} = -161 + (10 * weight_{kg}) + (6.25 * height_{cm}) - (5 * age) \tag{2.4}$$

2.1.3 Trending Graph

Humans are social animals and may care not only how well they do in terms of personal goals, but also how they fare with respect to others. Therefore, we provided the user with trending information [Fig. 2.4]. The trending graph gives an overview of the user's individual activity vs. group activity. The blue curve represents the median user performance and the green bar represents the percentage goal achieved by the user on specific days. The user of the app can tap to toggle between month and week view.

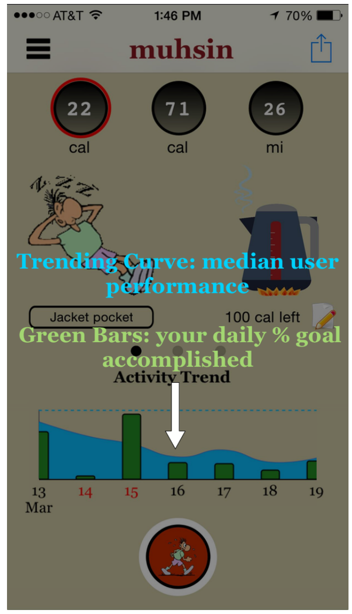


Figure 2.4: Trending Graph. The Activity trend graph displays user vs. group activity.

2.1.4 Design Changes

In the old and the new iBurnCalorie, a walking animation on the home screen corroborates that the app is responding to movements and counting calories. If the user gets in her/his car and starts driving, the application automatically switches to the car mode and records the miles driven. The transition between walking and driving is automatic. However, the user should explicitly switch the app to biking mode (by horizontal swipe on the cartoon animation) to record calories burned from biking.

We have added one more animation to the new iBurnCalorie. In the new iBurnCalorie, while the user is on the walking and biking modes, there is a carafe which shows the user's daily goal. The goal is customizable from the "Set Goal" screen [Fig. 2.2]. An empty carafe indicates that the user has achieved her/his daily goal.

In the new iBurnCalorie, tapping the hamburger menu button (top left corner of the screen in Fig. 2.1a) reveals several options: maps, goal setting, profile, and settings [Fig. 2.5]. Selecting the map button reveals TraceMap [Fig. 2.6a], OzoneMap [Fig. 2.6b] and ParticleMap [Fig. 2.6c]. Tracemap draws the user's walking, biking, and driving activity on a map. Integrated OzoneMap [16], and ParticleMap [2] let the user quickly check if it is suitable to be outdoors for a physical activity session.

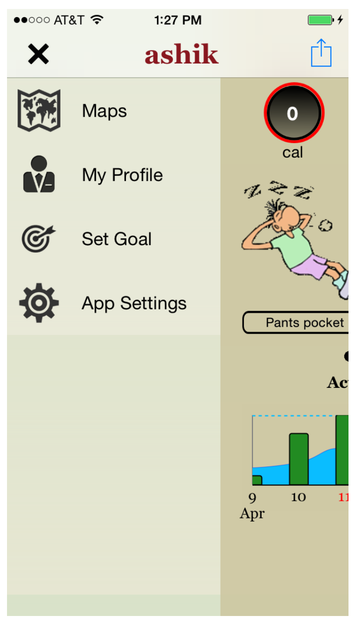
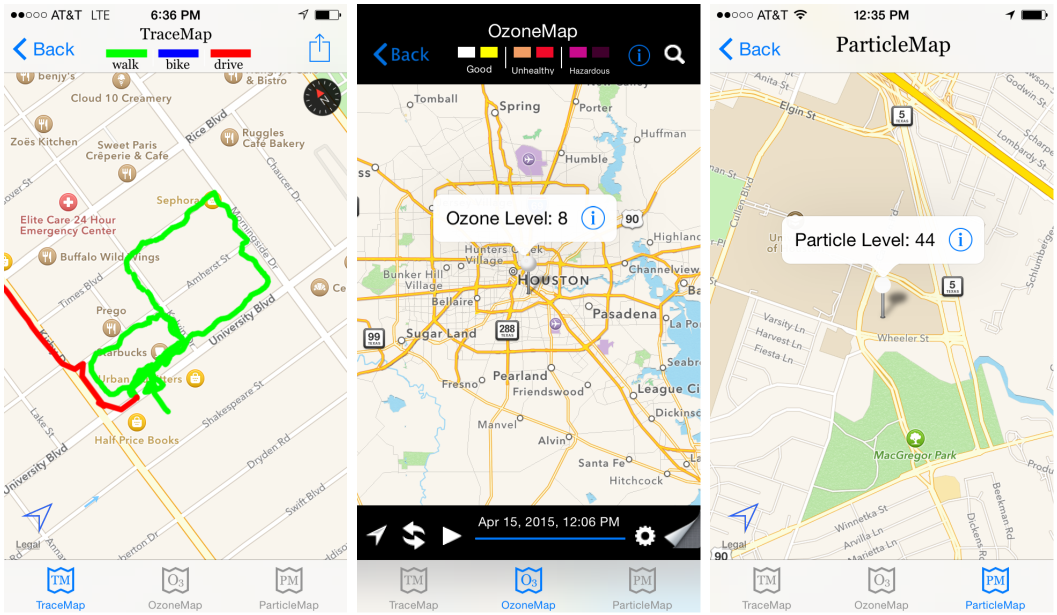


Figure 2.5: Application Menu



(a) (b) (c)

Figure 2.6: Maps. 2.6a shows the TraceMap, 2.6b shows the OzoneMap, and 2.6c shows the ParticleMap.

2.2 Software Design

The new iBurnCalorie application is developed on the iPhone platform using the Swift [6] and Objective - C [5] programming languages. Our newly redesigned application uses storyboards and the autolayout introduced by Apple [7] [8]. Using storyboards and autolayout allows for quickly adapting the application to various screen sizes. Data storage and processing happens on the application backend server. The backend server consists of the MySQL database for data storage and the PHP web server for communicating between the iPhone app and the database server. The server also hosts Groovy scripts which automatically generate trending data at the end of each day. The client, the iBurnCalorie iPhone app, communicates with the server via PHP. Fig. 2.7 gives an overview of the entire process.

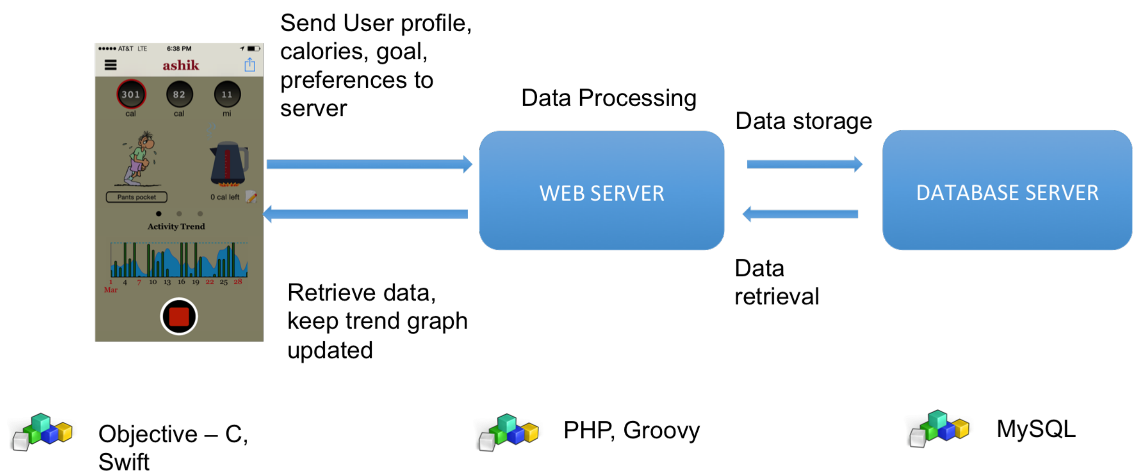


Figure 2.7: Application Architecture. The figure illustrates how the application and the server communicates with each other.

Chapter 3

Methods and Results

In this chapter, we present the data collected and analyzed from the new and the old iBurnCalorie.

3.1 Data Collection

We explored the data from the old version of iBurnCalorie between February 14, 2014 to April 2, 2014 and the new version between February 14, 2015 to April 2, 2015, a total of 48 days in both test groups. We used only users who used the application for at least 10 days in both groups. Based on these criteria we had nine users from old iBurnCalorie, and 12 users from our new iBurnCalorie. We made box plots and ran t-tests to ensure that the two samples were not significantly different in terms of age and BMI [Figs. 3.1, 3.2]. We ran two-sample test to check for equality of proportions for gender distribution [Fig. 3.3] and found that the two samples were

Figure 3.1: Age Distribution.

not significantly different. The statistical analysis was done at $\alpha = 0.05$.

3.2 Data Analysis

Before we performed our analysis, we had to normalize the calories expended by users of iBurnCalorie. We examined the percentage of caloric goal accomplished by the users, instead of the raw calories expended using Eq. 3.1.

$$\%Goal_{accomplished} = Calories_{burned}/goal_{calories} * 100 \tag{3.1}$$

For the new iBurnCalorie, we knew the user's goal because it is directly reported from the app to the server. However, the old iBurnCalorie neither followed the same

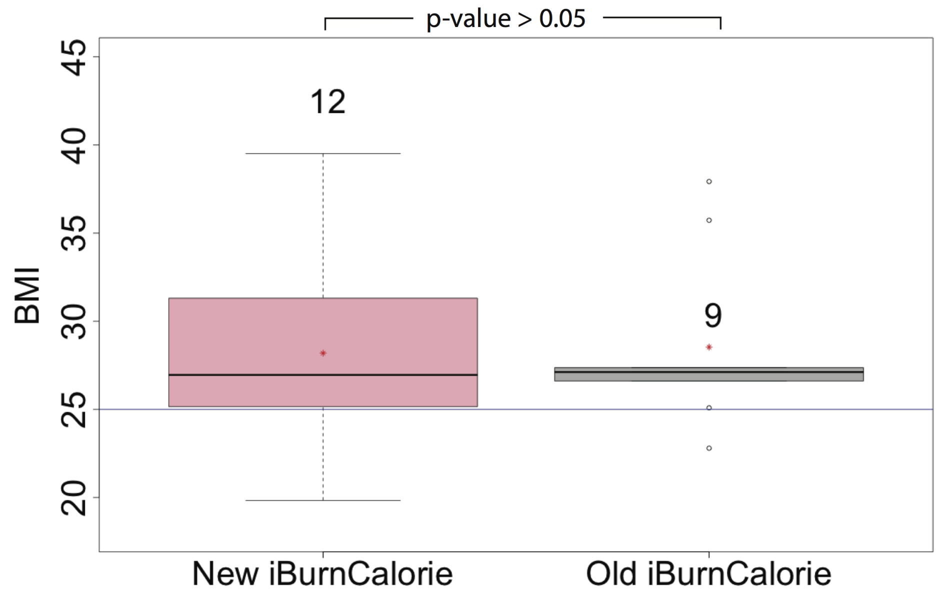


Figure 3.2: BMI Distribution.

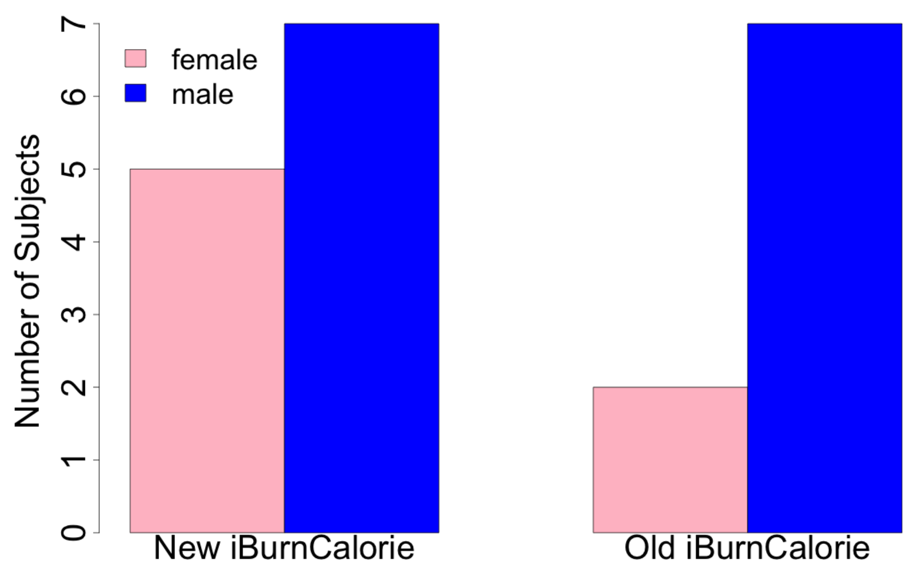


Figure 3.3: Gender Distribution.

design, nor had a ready goal on which we could perform comparison. Therefore, we reverse-engineered the goal. We first calculated the BMR of the user using Eq. 2.4 and 2.3. Next, we checked if their BMI were greater than 25 (overweight category). If it was, then we calculated their ideal weight (assuming a healthy BMI of 23) using Eq. 3.2. Once we had the ideal weight, we calculated their ideal BMR using Eq. 2.4 and 2.3. Finally, we computed their goal by subtracting their ideal BMR from their current BMR, using Eq. 3.3. For people with normal BMI and weight maintenance modes, we set a minimal goal of 100 calories.

$$Weight_{lbs} = (BMI * Height^2_{inches})/703 \tag{3.2}$$

$$Goal_{calories} = BMR_{current} - BMR_{ideal} \tag{3.3}$$

With the two groups ready for comparison, we first looked at the subject-level comparison illustrated in Figure 3.4. It can be seen that the number of data points for the new iBurncalorie users is higher than that of the old iBurncalorie users. Therefore, we looked at the usage comparison between the two groups and this is shown in Fig. 3.5. It is clear in Figure 3.5 that our new iBurnCalorie is being used more heavily than the old iBurnCalorie. We further checked for the difference in mean goal achivement between the two groups and show our results in Fig. 3.6. We found that when the users in the two groups were active, they did not significantly differ in caloric goal accomplishment.

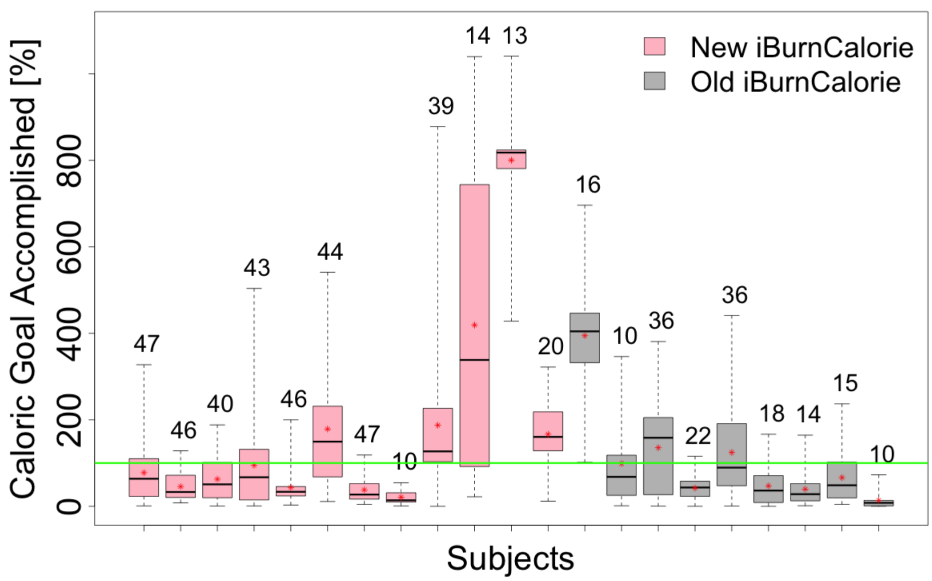
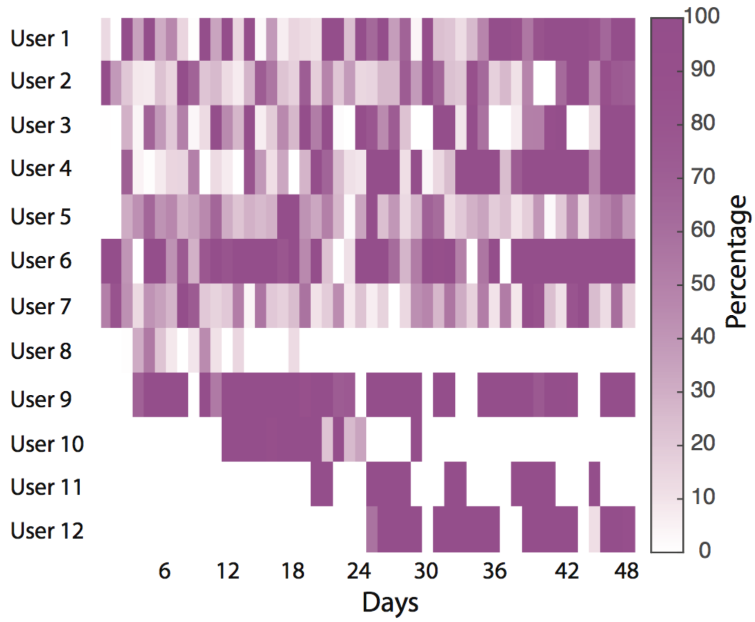


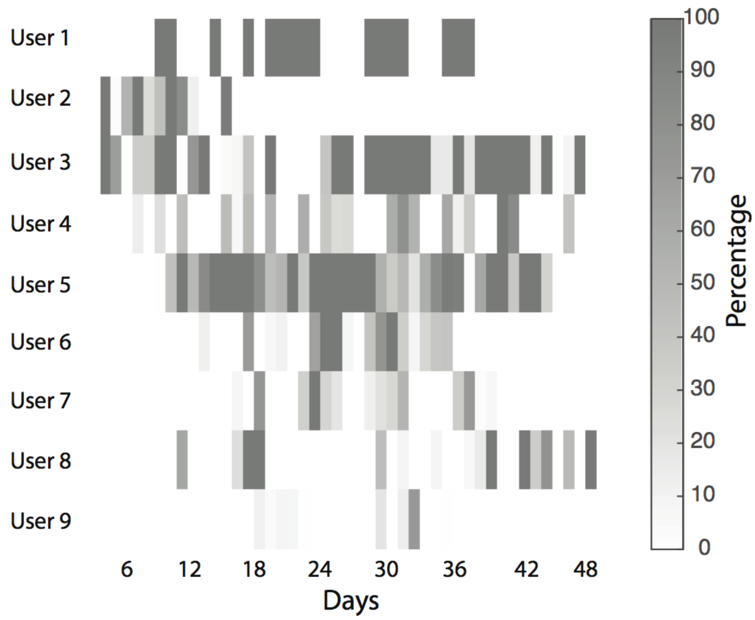
Figure 3.4: Subject-Level Comparison. The y-axis represents the percentage of goal accomplished. On the x-axis we have each person's individual box plots. The green line represents the 100% goal achievement. The number on top of each box plot represents the number of data points (i.e., distinct days) for the user during the observation period.

Next we created a line chart of the users' caloric goal achievements over time, as shown in Fig. 3.7. We noticed that there may be a periodic trend. We wanted to investigate whether there exists seasonality in the users' behavior. For this we performed wavelet analysis using signal extension techniques. We chose mother wavelet Daubechies 3 (DB3) because it had a shape which corresponds to dispersed high activity over few days [see Fig. 3.8]. We then created the wavelet power graph which represents the most dominant signal; the most dominant signal (the peak) indicates the underlying behavior, this is shown in Fig. 3.9. We then computed central frequencies for our new iBurnCalorie and old iBurnCalorie. We obtained a seasonality of 6.25 days for the new iBurnCalorie and 3.75 days for the old iBurnCalorie. In other words, it takes about 6 days for a person using the new iBurnCalorie to complete a full usage cycle, which is longer than when using the old iBurnCalorie.

Looking at Figure 3.7 we can also notice that there may be an increasing trend in goal betterment with our new app. Therefore, we performed linear regression [Fig. 3.10] to check for goal betterment behavior. We found significantly increasing trends of goal achievement for users of the new iBurnCalorie. So for our observation period, the new design is effective at helping users achieve higher goals then they did with the old app version.



(a)



(b)

Figure 3.5: Usage comparison between new iBurnCalorie [3.5a] and old iBurnCalorie [3.5b].

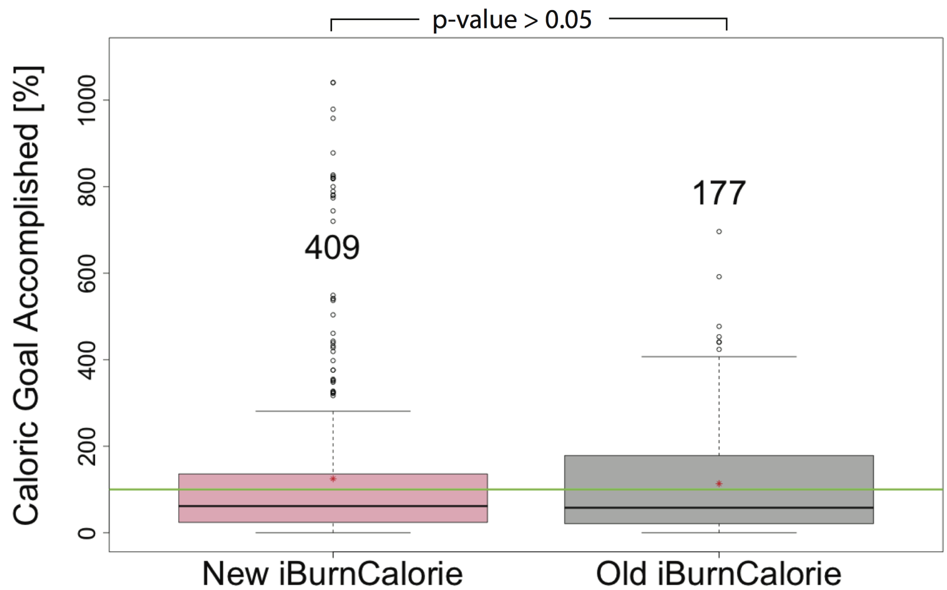


Figure 3.6: Comparison of goals achieved between new and old iBurnCalorie.

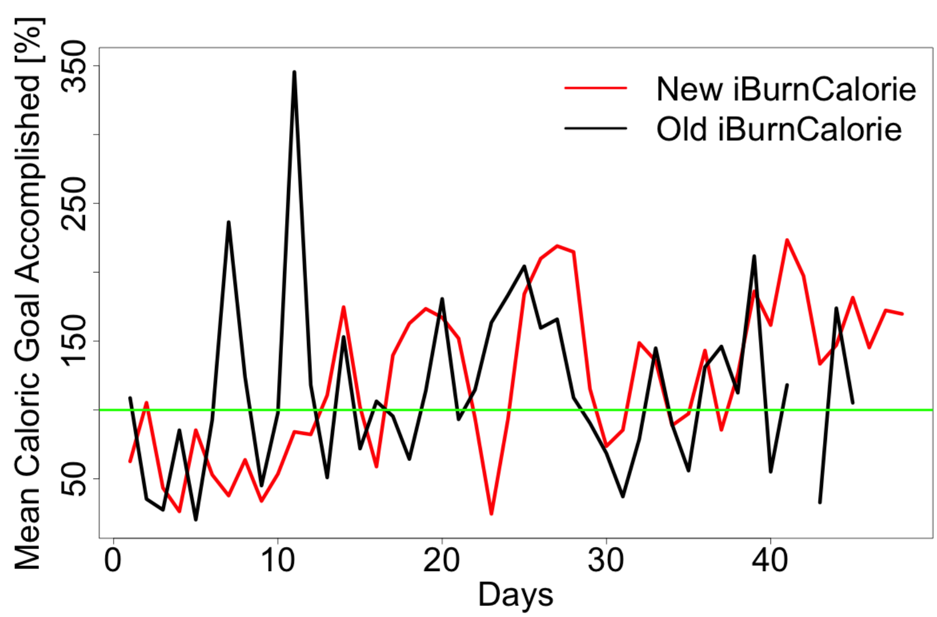


Figure 3.7: Caloric Goal Accomplished Over Time.

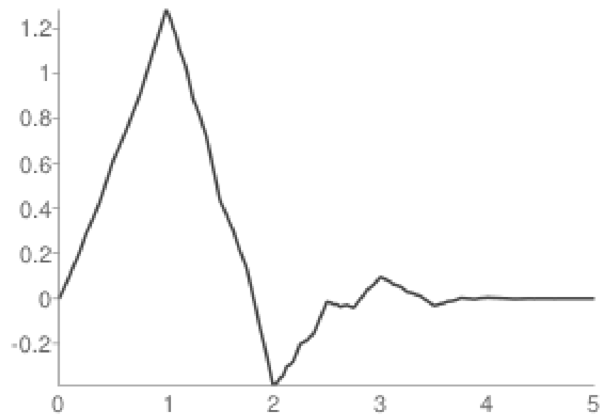


Figure 3.8: Daubechies 3 Wavelet Function. This figure represents the Daubechies 3 wavelet scaling function [1].

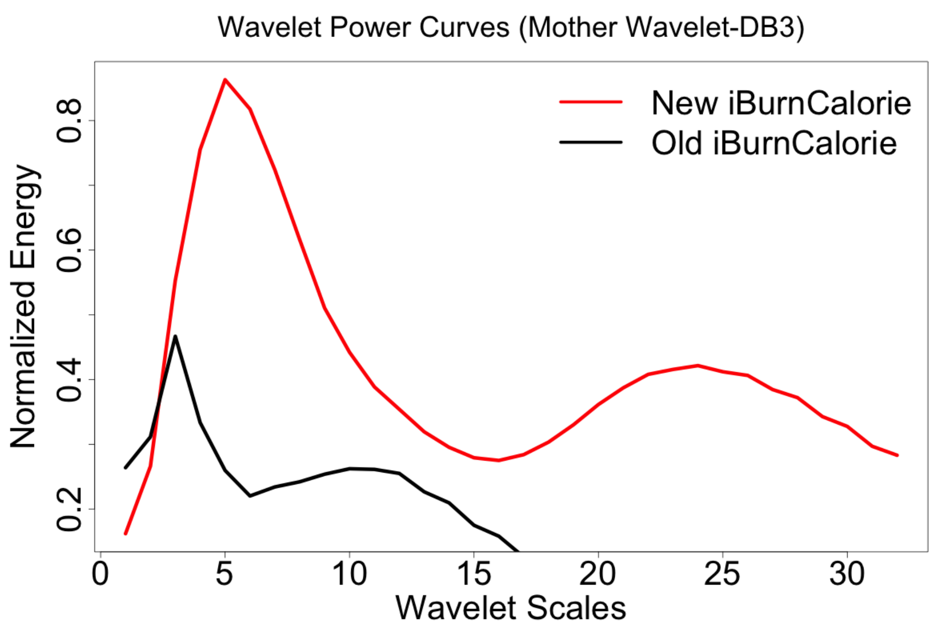


Figure 3.9: Wavelet Frequency Curve.

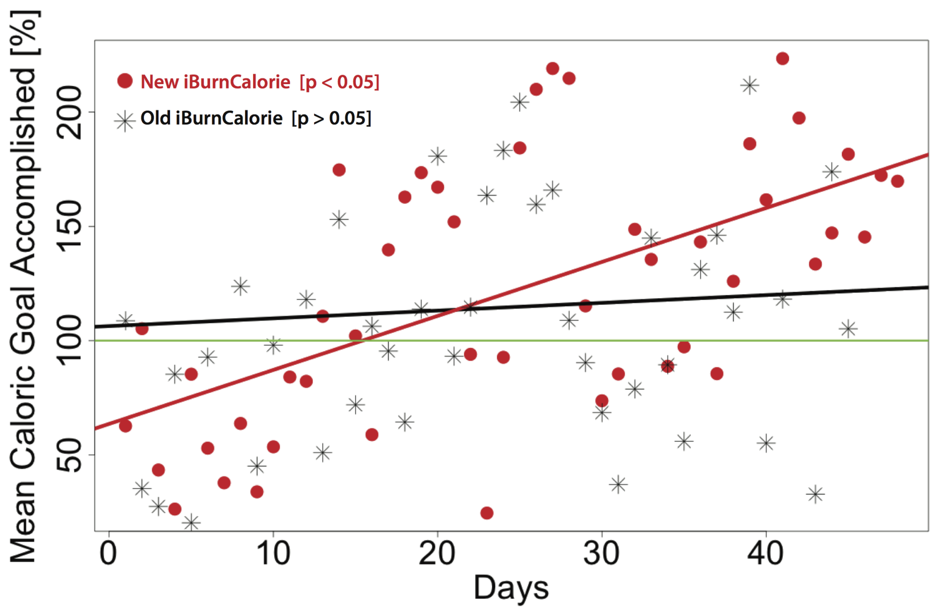


Figure 3.10: Linear Model. Users of new iBurnCalorie show significant improvement in goal achievement.

Chapter 4

Conclusion

As discussed in this thesis, some of the top-rated smart health applications lack simplicity and optimized goal setting. Therefore, we set out to redesign our application based on simplicity and minimalism, focusing on meaningful and personalized health goal. Our results support that optimized goal setting, and simple and minimal app increases app usage.

We conclude that the subjects using new iBurnCalorie app were physically active on more day compared to the old version, had longer seasonality periods and exhibited significant goal increasing trend. Therefore, our assertion that authoritative directions conveyed with single-minded simplicity do infact, have better chances than prevailing methods to keep the user of a smart walking app engaged holds true. App developers should focus on designing their health applications with a personalized and optimized goal and keep the app simple and minimal.

4.1 Future Work

Directions of future research should be to perform a comparative study of the our new iBurnCalorie app with other top-rated smart walking apps. Computing accurate calories is of utmost importance. To be as accurate as possible, surface incline needs to be considered in mobile applications. Currently applications assume level ground for calorie computations. Based on our preliminary work [15], we will incorporate surface incline in the next revision of iBurnCalorie.

Appendix A

Software Updates

We refactored the new iBurnCalorie application to create a reusable calorie calculator framework. The framework allows any iOS developer to compute calories from walking and biking using our algorithm [4]. This framework is available upon request to any developer from the project page [http://iburncalorie.times.uh.edu]. The calories are calculated without exposing any of the implementation details of our algorithms. Our framework provides the developer with two function calls, one for computing calories from biking and another for computing calories from walking. The framework can be imported in any iOS project via a simple drag and drop. Our framework accurately calculates calories from iPhone placed at various locations such as waist, pants pocket, jacket pocket, arm, hand, hand bag.

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