Utilization of Personal Health Informatics Through Intermediary Users

Author:
Ntwa KATULE

Supervisors:
Dr. Melissa DENSMORE and
Prof. Ulrike RIVETT

A thesis submitted in fulfilment of the requirements
for the degree of Doctor of Philosophy

in the

Department of Computer Science

February 2017

Declaration of Authorship

I, Ntwa KATULE, declare that this thesis titled, 'Utilization of Personal Health Informatics Through Intermediary Users ' and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for a research degree at this University.

- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.

- Where I have consulted the published work of others, this is always clearly attributed.

- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.

- I have acknowledged all main sources of help.

- Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself.

Signed:

_____

Date:

_____

"Education is what remains after one has forgotten what one has learned in school."

Albert Einstein

UNIVERSITY OF CAPE TOWN

Abstract

Faculty of Science
Department of Computer Science

Doctor of Philosophy

Utilization of Personal Health Informatics Through Intermediary Users

by Ntwa KATULE

There is an increasing prevalence of chronic diseases that are associated with living unhealthy lifestyle in both developed and developing world contexts. In order to help combat this unfavourable trend, public health researchers are advocating towards shifting care to the hands of citizens through utilization of personalized interventions . The objective of these initiatives is to support individuals beyond the point of care. ICTs, specifically mobile phones coupled with sophisticated persuasive mechanisms such as gamification or simple strategies such as SMS reminders provide an opportune platform for delivery of personalized interventions that target health behaviour change. In order to support delivery of such personalized interventions, researchers in human-computer interaction have developed an area of research referred to as personal informatics, which focuses on data collection and feedback mechanisms. These approaches aim at supporting individuals to be able to quantify different aspects of their lives through self-reflection. These systems have been developed with motivational affordance to sustain their utilization by end users. However, such systems are developed with only one user in mind of which is a direct user of technology. Such systems may not scale well in contexts of indirect users of technology, meaning people who use technology through a facilitation of a human interface (intermediary user) situated between indirect users (beneficiaries of technology) and technology. Therefore, there was a need to explore how motivational affordance of a personal health informatics could be extended to work in the context of an interaction that requires a collaboration that leads to indirect usage. This was a collaboration between the person helping and the person being helped.

In order to understand design implications for indirect technology use in the context of a personal health informatics, several approaches were used to understand social dynamics that could affect utilization of technology through a human interface in between indirect users and technology. Prototypes of mobile self monitoring applications for physical activity and diet were developed and used as the starting point for uncovering unknown issues. As the result of evaluation of the aforementioned prototypes , the researcher suggested both social technical arrangements and prerequisites that increase the likelihood of success in utilization of such interventions. One of the important social technical arrangement was a prior social relationship between a human interface and a beneficiary of technology through a human interface. Self-determination theory was used to understand how motivation for collaboration between the two sets of users (the human interface and beneficiary user of technology) could be enhanced. Gamification, a design pattern inspired by games was found to be the source of a significant increase in perceived competence, an aspect of self-determination theory. Therefore, gamification was found to be a catalyst for increasing collaboration between a human interface and beneficiary user of technology provided that the two users that form a pair had a prior social relationship. The collaborative gamified system showed promising results towards

utilization of personal health informatics in the context of indirect usage. The most promising combination of a human interface and beneficiary user is the one that entails family members, possibly a child and a parent.

Despite the success of gamification in increasing perceived competence of the human interface, and hence collaboration between a human interface and beneficiary user, there are some design implications that need to be taken into consideration in order to understand how internalization of collaboration between two members of a pair working together could be improved. This entails exploration of features that support task mastery climate versus those that support ego-involved. Future research could also explore how different styles of parenting could affect the way the intervention is perceived by the two sets of users....

Acknowledgements

The acknowledgements and the people to thank go here, don't forget to include your project advisor. . .

Contents

List of Figures

List of Tables

Abbreviations

BBM	Black Berry Messenger
BMI	Body Mass Index
CHW	Community Health Workers
GPS	Global Positioning System
HCI	Human Computer Interaction
ICT	Information and Communications Technology
ICTD	Information and Communications Technology and Development
MMS	Multimedia Messaging Service
NEAT	Non-Exercise Activity Thermogenesis
PDA	Personal Digital Assistant
PSD	Persuasive System Design
RCT	Randomized Controlled Trial
SIM	Subscriber Identity Module
SMS	Short Messaging Service
USSD	Unstructured Supplementary Service Data
URL	Uniform Resource Locator

This work is dedicated to my great parents, my father, Andalwisye, and my late mother, Mary for supporting me throughout my academic journey. . .

Chapter 1

Introduction

1.1 Background

Obesity and overweight are currently global health concerns. A systematic review by Guh et al. (2009) concluded that both overweight and obesity are associated with increased incidence of multiple co-morbidities including type 2 diabetes, cancer and cardiovascular diseases (CVD). The number of people who are considered to be either overweight or obese stands to an approximation of 1.3 billion people (Steyn et al., 2006). A survey by Abegunde et al. (2007) which included a total of 23 low-income and middle-income countries had projected a loss US\$84 billion of economic production in between 2006 and 2015 from heart disease, stroke, and diabetes alone in the absence of any significant measures put in place to intervene.

Co-morbidities that are associated with obesity are likely to inundate health care systems (Pollak et al., 2010). At the moment health-care systems have failed to optimally treat chronic conditions such as diabetes due to lack of time to continuously provide patient care which is essential in management of chronic conditions (Quinn et al., 2008). Resources are insufficient to deal with an overwhelming increase in number of patients; hence there has been suggestions emphasizing on moving part of the care to the hands of patients (Årsand et al., 2012). This need calls for innovative and citizen-centric interventions to foster lifestyle changes in order to, both prevent or delay onset of chronic conditions in poulations and also supporting of patients in self-management of a chronic conditions in order to reduce the burden on healthcare systems (Årsand et al., 2012; Korhonen et al., 2010; Higgins, 2016). There has been a growing number of initiatives by both commercial and research communities in development of wearable sensors and mobile applications that can nudge individuals to eat healthy and increase their level of physical activity (Chen and Pu, 2014). Citizen centric interventions are now possible due

to the current advancements in hardware and software technologies which have facilitated creation of opportunities for automation of health self-management processes (Årsand et al., 2010).

One interesting development trend in both academia and industry is the use of mobiles in health. The mobiles have become an effective way for "just-in time" delivery of interventions that target psychological processes (Hsu et al., 2014). These devices are currently omnipresent and people carry them most of the time (Mattila et al., 2008); hence their presence brings a "kairo factor" in delivery of interventions that target both health promotion (Pollak et al., 2010) and persuasion (Hsu et al., 2014). Smartphone based applications have been rapidly gaining popularity as effective tools to support delivery of personalized health information (Handel, 2011). One of the prevalent adoption of mobile health apps is their use in self-monitoring to augment *cognitive behaviour therapy* - treatment of behaviour in clinical settings (Mattila et al., 2008; Medynskiy and Mynatt, 2010). These apps facilitate data collection of one's health parameters through inbuilt tools such as GPS, accelerometer (body activity sensor), etc; hence present an innovative way of monitoring and improving both health and fitness (Higgins, 2016). In order for such tools to support changes in health behaviour and promotion of healthy lifestyle, theory based strategies such gamification (for enhancement of motivation), enabling self-reflection through goal setting and feedback (for improvement of self-efficacy), and SMS reminders are often applied (Higgins, 2016; Consolvo et al., 2009; Cole-Lewis and Kershaw, 2010; Hamari et al., 2014a,b). However, such tools have limitations if there were to be utilized in specific contexts. The basis of the research problem for this study was on a limitation that is related to developing world context but can as well scale to a context of developed world. The research problem is as reported below.

1.2   Statement of the Problem

A review by Higgins (2016) presented evidence that self-monitoring apps can help patients reach their health and fitness goals. Also these apps can support individuals who are not patients to become aware of their behaviours which is an important step towards taking actions that are necessary in living a healthily lifestyle. However, such apps have limitations as they don't support specific interaction models that accommodate sharing of devices and indirect usage. Such mode of interaction are prevalent and relevant in the context of developing world ; hence self-monitoring applications that are designed for direct use may not replicate well to some populations of users (Sambasivan et al., 2010; Kaplan, 2006), especially in the context of users that face barriers of direct access to user interfaces or technology (Kumar and Anderson, 2015). Typically, self-monitoring apps

utilize specific theory informed motivational affordances in order to enhance engagement of end users but such incentives have been designed only for a direct user as are not supported in a situation of where you have at least two layers of users that consists of an intermediary user who acts as a bridge for an indirect user who is a beneficiary of information in a self-monitoring app. Such a scenario of intermediated technology is shown on Figure 1.1 which is profoundly explained by Sambasivan et al. (2010) in the perspective of activity theory (Kaptelinin and Nardi, 1997), of where in a direct inter-action, a computing device or system is an object with an affordance of an activity of which an end user can perform on the object, while in an intermediated interaction there is an addition layer of human interface (intermediary user) responsible for translating intents of a beneficiary user into actions by carrying out activities to a computing device or system on behalf of an indirect user (beneficiary user).
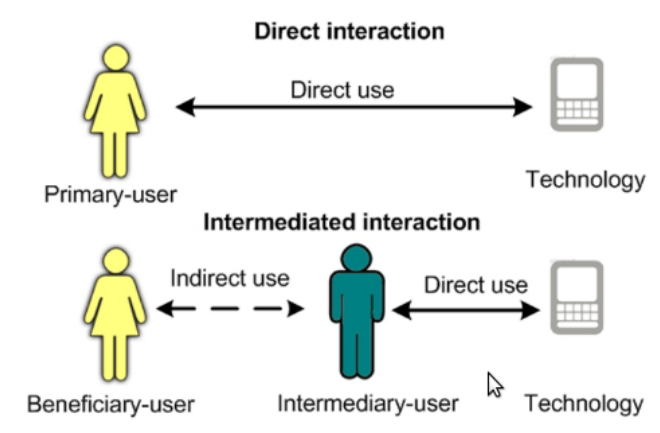
FIGURE 1.1: Direct and intermediated interactions (Sambasivan et al., 2010).

This research explored of how one could support a personal health informatics technology of which its usage is facilitated by intermediaries users on behalf of beneficiary users (indirect users). Despite a vast amount of literature on *intermediated technology use*, such persuasive technologies have not been extensively explored in this context. Persuasive technologies tend to have their unique design considerations, and intermediated technology use has its socio-technical aspects; hence one has to understand factors to consider and how to go about implementing a useful intervention that can work in such a complex context. This study had two main research questions as presented below.

1. What is the role social-technical settings in motivation for intermediated use in the context of a gamified self-monitoring application targeting promotion of healthily eating and physical activity?

    Sub-questions

a. What social factors have impact on intermediated use of a gamified self-monitoring application?

b. To what extent those social factors affect motivation to engage with a gamified self-monitoring application in intermediated use context?

2. What value is added by framing gamification as a motivation incentive that is applied in intermediated use context of a gamified self-monitoring application targeting promotion of healthily eating and physical activity?

Sub-questions

a. How the presence of gamification affects the relationship between an intermediary user and beneficiary user?

b. What is the impact of gamification in supporting self-determination of intermediary users to engage with a self monitoring application in intermediated use context?

c. What is the impact of gamification in supporting self-determination of beneficiary users to engage with a self-monitoring application in intermediated use context?

d. What is the impact of gamification in frequency of utilizing the self-monitoring application in intermediated use context?

e. What is the impact of gamification on motivation of beneficiaries to self monitor diet?

f. What is the impact of gamification on motivation of beneficiaries to self monitor physical activity?

g. To what extent gamification may encourage or discourage internalization of intermediated use behaviour?

1.3 Research Contribution

This research was grounded by user evaluations, ideas from past studies, and existing theories of human motivation. In total there were three user evaluation studies. These series of user studies were carried out in three townships in South Africa at different intervals of time. Each user study helped to uncover unique insights that were important in getting answers to the aforementioned research questions. Each user study consisted of several pairs of users. Each pair of users consisted one beneficiary user (a person who solicited help in using the self-monitoring application), and one intermediary user (a person who provided needed help to a beneficiary user to facilitate interaction with

the self-monitoring application). Beneficiary users elected their respective intermediary users and the pair had access to the app for a certain number of days before questionnaires and interviews were administered.

Data collection techniques consisted mostly of triangulation of app's usage logs, interviews, and questionnaires. In order to solve the problem, prior to carrying out any prototype development and evaluation, the study kick-started with a contextual investigation to uncover preliminary understanding of users' context through administering semi-structured questionnaire to adult participants who were opportunistically approached in a hospital settings in Cape Town. Contextual investigation was followed by iterations in development and informative evaluations of mobile application prototypes. Motivational affordances implemented on prototypes included gamification features such leader-boards, badges, avatars, virtual pets caring (garden and fish tank), and social interaction features. Through the course of eliciting feedback from user studies, I as the researcher was able to generate insights in an iterative manner of where each iterative user study informed the formulation and execution of a successive user study.

From informative evaluations, the study concluded with a summative evaluation which had an objective of measuring the effectiveness of using gamification in promotion of intermediated use in the context of self-monitoring applications.

The contribution of this research is mainly on understanding of social dynamics and motivational affordances to consider when designing a personal health informatics (PHI) for intermediated use. In this dissertation it is suggested that rather than designing a PHI only for the beneficiary alone, one can design for intermediated use, explicitly acknowledging the presence of intermediary user as facilitators of access to a self-monitoring application. This research demonstrated that it is feasible to frame the design of a personal application in way that promotes collaboration between an intermediary user and a beneficiary user; hence reaching the goal of motivating intermediated use. The dissertation highlights some social configurations that are crucial for a self-monitoring application in intermediated use context. The dissertation further emphasizes of the importance of pairing users within family settings to foster an environment that encourage intermediated use. The study indicated that when a pair consists of immediate family members, then the prior social relationship may promote internalization of help-giving behaviours on the side of intermediaries. Prior social relationship appears to be a prerequisite for setting up an intervention and it can provide rationale for intermediaries to perceive gamification as something that is fun to use but at the same time as something done to support a good cause which in this case it was to help someone you care about. With presence of that care, and by adding a gamification layer, collaboration and family

bonds show indications of improvement, however, in some situations competition appears to harm an existing family bond between members of a pair instead of promoting it especially when one member of a pair feels of being let down by the other member of a pair. Strengths and weaknesses of different motivational affordances in-terms of promoting aspects of autonomy, competence, and relatedness are also discussed in details in order to offer insights to both designers and researchers in designing of future interventions.

1.4 Thesis Organization

The following is an organization of this thesis. Chapter 1 is ***Introduction*** which provides the background information of the problem, research questions, and lastly the contribution of this research to knowledge. Chapter 2 is ***Literature Review*** which mainly covers the theoretical underpinning of this research in terms of related work and the conceptual framework that lays a foundation for this research. Chapter 3 is about ***Study Context*** which situates this work into South African context by providing a rationale why carrying a study in South African townships was important. Chapter 4 presents ***Contextual Enquiry*** that was conducted at the beginning of the study to understand how technology is being utilized in general in the context of older adults who are prospective beneficiary users of the technology. In addition this contextual enquiry aimed to understand if there were particular usage of technology that were health related. Chapter 5 is ***Prototype I*** of where it describes development and evaluation of the first prototype. Preliminary user requirements used in development of the first prototype were formulated as the results of insights gained from both preliminary findings of the contextual enquiry, and ideas grounded from literature. Chapter 6 is ***Prototype II***, this was an improvement of the first prototype. This improvement was as the result of both qualitative feedback from evaluation of the first prototype and researchers' observation of context in the field. Chapter 6 is ***Summative Evaluation*** of where the second prototype was evaluated with a placebo group to discern the isolated effect of gamification from existing family bonds. Chapter 7 is ***Conclusion and Future Work*** which discusses how research questions were addressed and highlights reflection from the three evaluation studies by providing insights in terms of design lessons based on strengths and weaknesses of the gamified personalized application for intermediated use. In addition, this last chapter concludes on takeaways from this research and introduces the basis for future research.

Chapter 2

Literature Review

2.1 Behaviour Change Support Technologies

Research on ubiquitous computing to support behaviour change has received a significant amount of attention in a myriad of domains such as computer science, human-computer interaction, health care, etc.. One of the core research areas is on how to design incentive systems that are emotionally engaging and provide timely feedbacks in order to persuade people to change their behaviors (Nakajima and Lehdonvirta, 2013).

One of the early pioneers to formalize behaviour change technology as an area of research was B.J. Fogg[1] who coined a term "captology" which is an acronym for *Computers As Persuasive Technologies* (CAPT-ology), with focus on the planned persuasive effects of computer technologies (Fogg, 1999). In persuasive systems, persuasion is intentional and usually implemented through persuasive stimuli; hence providing a system with an ability to persuade (Hamari et al., 2014a). Persuasive technologies have applications in domains such as health-care, education and training, environmental sustainability, etc..

According to Langrial (2012), the evolution of research on behaviour change technologies through the realms of computing research started with digital interventions in early 1990s which were basically for intervening behaviours in the preventive health area primarily through reminders; to persuasive technologies - systems that implement various software functionality that utilize approaches such as social learning or comparison etc; to the current behaviour change support systems (BCSS) which provide models and frameworks for designing and evaluating persuasive technologies. Oinas-Kukkonen (2013) defined a BCSS as "a socio-technical information system with psychological and behavioural

---

[1]http://bjfogg.com/

outcomes designed to form, alter or reinforce attitudes, behaviours or an act of complying without using coercion or deception".

Separate models (frameworks) to guide the design and evaluation of persuasive technologies have been proposed since models from information systems such as a *Technology Acceptance Model* (TAM) have limitations with regard to understanding the effectiveness of persuasive technologies (Oinas-Kukkonen and Harjumaa, 2009). Persuasive technologies' models tend to provide nuanced features and characteristics that define such systems. Fogg (2009a) recommended a behaviour model for persuasive design which asserts that for a person to perform a targeted behaviour, he or she must (1) be sufficiently motivated, (2) have the ability to perform the behaviour, and (3) be triggered to perform the behaviour. Fogg (2009b) also recommended a behaviour grid that one could guide a person intending to design a persuasive technology. In this behaviour grid, persuasive strategies are matched to targeted behaviours.

Oinas-Kukkonen and Harjumaa (2009) extended Fogg's work (Fogg, 2009a) with a more comprehensive model known as a *Persuasive System Design* (PSD) model which suggested three initial steps: (1) analysis of the persuasion context, i.e. with focus on the intent of persuasion and context of use, user, and technology; (2) selection of persuasive features to use; and (3) selection of persuasion strategies to use i.e. whether to use a direct or indirect route of persuasion. The PSD model also outlined 28 design principles discerned into the following five categories: (1) *primary task support*, which includes activities such as, reduction of complex behaviours into simple tasks, guiding the user through experiences while persuade along the way, tailoring of persuasive information to factors relevant to a user group, personalization of content, and self-monitoring for users to keep track of their performance towards their specified goals; (2) *dialogue support*, which includes praises, rewards, reminders, similarity, liking, and social roles; (3) *system credibility support*, which includes trustworthiness, expertise, surface credibility etc; and (4)*social support*, which includes social learning, social comparison, and competition.

An extension to the PSD model was an *Outcome Change* (O/C) matrix of which one could use when analysing an intent of persuasion (Oinas-Kukkonen, 2013). The O/C matrix matches the type of change that needs to be applied with a specific outcome. A change could either be of compliance (C) or behaviour (B) or attitude (A), nature. While an expected outcome could be forming, altering, or reinforcing any of the aforementioned types of change. The extended PSD model with O/C matrix is called BCSS as mentioned in the classes of behaviour change systems above. BCSS is considered to be the foundation for studying persuasive systems and it is meant to provide a base for analysis, design, and evaluation of persuasive technologies. The next section highlights how behaviour change technologies have been applied in health domain.

2.2 Behaviour Change Technologies for Health

Health-care providers are eagerly seeking for innovative solutions that could help in monitoring and improvements of patients' health (Higgins, 2016). Innovative ways to support health promotion and management are in need to respond to the health care crisis as the result of unprecedented increase in prevalence of lifestyle-chronic diseases (Årsand et al., 2010). Health-care systems do not have sufficient resources to cope with the increasing burden of chronic diseases (Quinn et al., 2008; Årsand et al., 2010); hence these innovative ways aim at supporting the advocacy of shifting from physician centred care to patient-centred care (Korhonen et al., 2010; Higgins, 2016). Literature has demonstrated the dominance of persuasive technologies targeting health behaviour change. For instance one recent systematic review of 95 studies that examined the ability of persuasive technologies to persuade, had approximately included 47 % studies that targeted domains of health and exercise (Hamari et al., 2014a). The remaining 53% was shared by several domains such ecological consumption and/or behaviour (21%, second highest), education/learning economic (11%), etc.. Therefore, this indicates that health is an important area of concern when the notion of persuasive technologies comes in mind.

Chatterjee and Price (2009) classified three generations of technological evolution of hardware and software utilized in implementations of behaviour change interventions in health. The first generation started to emerge from 1960's and it was characterized by the prescriptive nature of information flow from physician, health care provider, or technology-based system, to a health care recipient. Decades worth of research has demonstrated that phone-based or simple messaging technologies could improve the quality of health care management and clinical outcomes. The second generation is characterized by the descriptive nature of information interaction between an end user and a persuasive technology. Examples of systems in the second generation include interactive websites, personal data assistants (PDAs), which facilitated and automated tracking of basic health parameters through self-reporting diaries/journals and simple context aware sensors. The third generation extends the second generation by providing body-wearable sensors that support advanced health monitoring, use of context-aware computing to determine when to deliver "just in time" messages. The second generation was dominated by the use of PCs and later cellphones while the third generation was dominated mostly by cellphones and ubiquitous computing devices. The future generation is expected to be the one that will entail ubiquitous computing integrated seamlessly into people's daily lives and it will be supported with data mining techniques (Chatterjee and Price, 2009).

The first and second generations systems are the ones that have received most appraisal because of existing randomized clinical trials. Their dominance is proved by the preponderance in publications that report on the use web based interventions integrated with SMS text-messaging on clinical settings. Existing systematic reviews (Cole-Lewis and Kershaw, 2010; Fjeldsoe et al., 2009; Krishna et al., 2009) reported more on the use of SMS reminders and feedbacks on areas of diabetes self-management, smoking cessation, and weight reduction therapy. There are mixed results on effectiveness of cellphone or other ICT interventions on weight loss production. For instance in one randomized controlled trial (RCT) that was carried out for a period of two years (Svetkey et al., 2015), its finding revealed that two intervention groups of which one was using only a smartphone app , and the other group using both a human coach and a smartphone app, both didn't result into a significant improvement more than a control group which was supplied with only pamphlets materials. In addition to mixed findings that are prevalent in such clinical trials, systematic reviews (Cole-Lewis and Kershaw, 2010; Kaplan, 2006) have also pointed out drawbacks in delivery of such interventions of which one of them points out to inability to scale well to specific demographics within resource constraint contexts i.e. in contexts of where technology and textual literacies, or sharing of technology among multiple consumers, may become a barrier to effective delivery of such health interventions. From persuasive technology literature perspectives it has also been observed that there is a gap between research in persuasive technologies and RCTs in public health settings. Literature from public health domain is being criticized for tending to lack adequate information on how individual systems are designed meaning such systems are usually poorly described since most work is being published by public health practitioners without involvement of computer scientists (Oinas-Kukkonen, 2013). Therefore, it is arduous to interrogate what systems attributes contribute to success or failure of such interventions.

Persuasive technologies provide means to personalize health information. Personalization of health information has been advocated within public health domain as it allows consideration of individual needs of a person and it also gives a targeted person, a sense of control over their healthcare (McCallum, 2012). The broad focus of this research was on personalized technologies that support both data collection and feedback for an objective of health persuasion. These systems are referred to as wellness applications or personal health informatics. Personal informatics is a class of interactive applications that support users to improve self-awareness of various facets of their lives by providing technological means to support in collection and analysis of personal data related to habits, behaviours, and thoughts (Li et al., 2011a, 2012). Utilization of personal health informatics in behaviour change is discussed on the next section.

2.3   Personal Informatics for Health Behaviour Change

A personal informatics system is effective for self-tracking of a behaviour because it augments the activity of *self-reflection* by complementing individuals in storing personal events intertwined with context of where such fine details of events would have been hardly recalled due to limitations in humans' memory (Li et al., 2010). A personal informatics system is capable of storing granular information about events and this what makes it harder for humans to memorize all that information. The goal of personal informatics systems is to support individuals in having a better understanding of their lifestyle or behaviours. These systems are important in promotion of positive behaviors in a myriad of domains such as healthy lifestyle (Korhonen et al., 2010), recycling (Comber and Thieme, 2013), energy conservation (Seligman and Darley, 1977), etc..

Research on personal informatics systems tends to focus on, effective ways of, collecting users' personal data in an effortless manner, and supporting for self-reflection through feedback mechanisms (Li et al., 2011b). Data collection is usually supported with context-aware sensors and self-reporting mechanisms. Sensors may be coupled together with a computing device for both analysis and feedback or may be coupled in an external device that transfer data through either wireless means or data cables, to a computing device responsible for analysis and feedbacks. Nakajima and Lehdonvirta (2013) proposed the use of a metaphor *"ambient persuasive mirrors"* to describe displays that could support self-reflection of one's own behaviour. These mirrors may be multifaceted and may apply transformation and integration of data from other sources, and their implementation can be on, personal mobile devices (Klasnja et al., 2009) or shared public interfaces (Lin et al., 2006).

Personal informatics systems can be applied in prevention of onset of chronic conditions by motivating healthy individuals to change their lifestyle. Specifically, these systems promote behaviours that are beneficial in, preventing weight gain or weight loss. These systems operate by facilitating logging of data related to personal behaviour. This act of behaviour logging can also be beneficial in self-management of chronic conditions as it provides support for a self-monitoring task. Self-monitoring is very essential in supporting cognitive behaviour therapy (CBT) within public health settings (Mattila et al., 2008), especially for individuals who are clinically obese (NIH et al., 2000). Health self-management programs usually ask participants to keep records of their activities, physiological variables and other health-related data; personal informatics applications can make this process simpler and easier (Medynskiy and Mynatt, 2010). For instance participants may record their daily calorie intake,and then have graphs that show trends of how far they have gone with reducing their intake. The essence of self-monitoring

is to promote self-awareness of one's behaviour. That consciousness is fostered through behaviour observation. And behaviour observation can be achieved through behaviour recording. Therefore, collection of data on one's own behaviour can viewed as an important self-assessment approach for helping patients to observe and react on their own behaviours (Rapp, 2014). This implies that with a self-monitoring system or app, processes of recording and self-reflection are simplified through technology.

Literature presents a wide range of mobile phone based personal informatics systems for promotion of physical activity, blood glucose monitoring, and healthy eating. Some of these are specifically for chronically ill patients e.g. "Few Touch Application" which targeted individual with *Type 2 Diabetes* (Årsand et al., 2010), and a system described by Arteaga (2010) that targeted teenagers with weight management issues. There also exists systems that target general populations, and used for promoting healthy eating habits and engagement in physical activity e.g. Fish'n'Steps(Lin et al., 2006), UbiFit Garden(Klasnja et al., 2009), Wellness diary(Mattila et al., 2008), ActivMon(Burns et al., 2012), PmEB(Lee et al., 2006), iCrave(Hsu et al., 2014), etc.

Models and frameworks for understanding both physical, social, psychological needs of users within the context personal informatics have been vastly explored. Kamal et al. (2010) presented a framework for designing a system that integrates online social networks and personal informatics to promote positive health behaviours. The framework was informed by theories from both health behaviour change and social networks. Li et al. (2010) proposed a model for understanding how people use personal informatics by transitioning between the following five stages: preparation, collection, integration, reflection, and action. The importance of identifying barriers at each stage is emphasized since these barriers may also cascade to later stages to hinder the process of data collection and self-reflection. In order to address cascading barriers, it was recommended that the design process should be carried out in an holistic approach that involves iterations between stages. The aforementioned model aimed at helping with the process of designing a personal informatics system. There are also studies that have explored design implications for data logging systems that support self-reflection. For instance Li et al. (2011b) highlighted that such tools should be designed to address six questions that users ask themselves when engaging with their personal data; these questions are based on, status towards achieving their goal, history for the purpose of discovering patterns that are crucial to the preferred behaviour, formation of goals to facilitate in attaining a preferred behaviour, discrepancies between their behaviour and goal, context of past behaviour in order to discover patterns, and discovering of factors that may affect their behaviours. The aforementioned questions are asked in two phases of which the user alternates in the course of using a personal informatics system. The two transition phases

of behaviour change are self-discovery and maintenance. In the self-discovery stage individuals collect a lot of data they can use to discover patterns in their behaviours. After discovering of a pattern they can move to the maintenance stage. The maintenance stage entails setting of a personal goal and monitoring of a status towards achieving that goal. Users don't stay permanently in one phase. It is possible for an individual in the maintenance phase to go back to discovery phase if there is a new unknown pattern that has emanated and appears to affect their behaviour. Another study by MacLeod et al. (2013) suggested factors that drive motivation of chronically ill people in engaging with their personal data as; curiosity, and self-discovery of what is happening in their health.

The most recent model to help in understanding how people use personal informatics systems, suggested that these systems are meant to be fully integrated into people's daily lives (Epstein et al., 2015a). This model extends Li et al. (2010)'s model, by splitting the preparation stage into *deciding to track* and *selecting tool* processes; and combining collection, integration, and reflection into tracking and acting. This model also includes further stages beyond tracking and acting and these were lapsing, and resuming tracking. From lapsing, issues that contribute to discontinuation or intermittent usage are explored, while in resuming tracking, issues such as switching of tools, incorporation of previous history/data while resuming to use are explored on this stage.

The last stage of the Li et al. (2010)'s model suggests on providing guidance to an end user towards an action. However, guiding an end user through an action/acting stage for the objective of minimizing barriers in execution of the action stage, can be perceived as an attempt to nudge individuals towards certain behaviours. There has been a debate from HCI research community of whether behavioural nudges are ethically accepted or not as some researchers are proposing a more neutral approach while others recommend application of intervals of behavioural nudges upon tracking (collection and reflection) activity. For instance, Munson (2012) advocates that the focus on personal informatics should be towards enabling end users to better know owns behaviour instead of applying behavioural nudges, and suggests that adoption should be voluntary. Also in Epstein et al. (2015a)'s model it is highlighted that sometimes people use personal tracking systems for other reasons beyond behavioural change goals such as instrumental benefits (i.e. to get rewards from location trackers like Foursquare), or out of curiosity. However, Epstein et al. (2015a), still shows that in most usage that is related to health domain i.e. in physical activity, behaviour change goal is a dominant motivational factor (Epstein et al., 2015a); hence suggestions on what actions an end user should take are inevitable. In addition to this, technology is considered not to be neutral (Oinas-Kukkonen and Harjumaa, 2009). Technology has a capability of presenting social cues that trigger emphatic responses from humans (Fogg, 2003). If no action is recommended,

still an action can come from within a person using the system as the result of self-reflection. According to Fogg (1998) cited in Oinas-Kukkonen and Harjumaa (2009), intent of persuasion can originate from either of the three sources which are: (1) from the people who create or produce interactive technology; (2) from people who give access to or distribute the interactive technology to others; and (3) from the people who use or adopt an interactive technology. The intent of persuasion may also come from within the person using a system that does not recommend or suggest any actions. The persuasion may be as the result of cognitive dissonance after self-reflection. People like their views of the world to be consistent and it also assumed that people always make rational and informed decisions (Oinas-Kukkonen and Harjumaa, 2009). By using personal informatics, individuals' decisions can be improved by being be able to see the discrepancies between their desired behaviours versus their performance (Comber and Thieme, 2013). If there are inconsistencies, then a cognitive dissonance is introduced which may mediate a change of attitude or behaviour in order to restore consistency between beliefs and actions (Oinas-Kukkonen and Harjumaa, 2009). Therefore, an act of tracking(collection and reflection) itself can mediate a behaviour change through cognitive dissonance. The motivation of usage of personal informatics in domains such as health and finance has been found to be related to a behaviour change goal (Epstein et al., 2015a). From this perspective, a basic personal informatics system with simply self-monitoring support can be viewed as a persuasive technology in contexts such as personal health and finance, because of its ability to trigger cognitive dissonance which can be considered as a persuasive stimulus. Knowing one self can be important in adoption of a better lifestyle. For instance one study found the use of pedometer alone (without other motivational affordances) increased physical activity by about 1 mile of walking per day (Bravata et al., 2007) cited in Albaina et al. (2009).

One of the common strategies to make cognitive dissonance more salient involves setting of personal health goals, which has been recently used in many developed systems i.e. Few Touch Application (Årsand et al., 2010). This idea is derived from a goal setting theory (Strecher et al., 1995). An example of a goal could be to walk for at least 30 minutes every day or to increase the number of times a person eats fruits and vegetables or to reduce the amount of starch in a meal. One way of tracking progress towards the goal is through feedbacks that may simply be implemented through SMS, or some sophisticated visualization approaches. The common data visualization techniques consist of charts and graphs. Beyond charts and graphs, the use of metaphors that requires users to take care of virtual pets is becoming prevalent as a means to emotionally engage users with their personal health data concerning physical activity and diet (Pollak et al., 2010; Nakajima and Lehdonvirta, 2013; Klasnja et al., 2009; Lin et al., 2006; Albaina et al., 2009). The use virtual pets has been used in promotion of behaviors such as drinking

of water (Lessel et al., 2016), recycling behaviours (Comber and Thieme, 2013), reduction of CO_2 emissions, and proper tooth brushing (Nakajima and Lehdonvirta, 2013), etc.. The most popular virtual pets are the ones that use plants or fish metaphors and these metaphors have shown promising results in supporting end users with their motivational needs. For instance Nakajima and Lehdonvirta (2013) described a situation of where participants felt guilty when their trees died. Another example is that of a Fish'n'Steps (Lin et al., 2006) application of where some of the participants were saddened when their fish appeared to be sad because participants had not walked enough steps. The aforementioned examples demonstrate how the use of virtual pets could invoke end users' emotional attachment with their virtual pets. Utilization of informal art displays in promotion of physical activity is also reported in literature (Nakajima and Lehdonvirta, 2013; Fan et al., 2012).

The motivational paradigms in persuasive technologies have also been extended to exploration of systems with social incentives that entail social collaboration, social interactions, social support, and competitions or social comparison for the purpose of enhancing engagement of end users (Ploderer et al., 2014; Chen et al., 2016; Epstein et al., 2015b; Reno and Poole, 2016), and this brings the notion of gamified personal health informatics (Chen and Pu, 2014; Lin et al., 2006; Han et al., 2014). Cooperation and competition features have been found to be among effective incentives in pervasive fitness applications (Chen et al., 2016). Also the use of social influence through social networks integrated with personal informatics is very promising. For instance in a Bin-Cam (Comber and Thieme, 2013; Comber et al., 2013) system they used social norms influence as a motivation strategy to encourage individuals within a household to be more conscious of their recycling behaviours by comparing themselves with other households. Bales and Griswold (2011) proposed the idea of interpersonal informatics systems that aim at making the social influence more salient to individuals using personal informatics systems. The authors of the aforementioned paper argue that personal choices are also as the result of the influence of social networks in which one participates. The essence of the aforementioned approach was to support individuals in becoming more aware of how those around them affect their habits, beliefs, and health. This idea of social influence is also explored by Ploderer et al. (2014) using the notion social interaction that ranges from minimal social traces of other people's activities to rich social interaction via social media, to systems that focus on collective use rather than individuals. Therefore, sharing of personal data is an important catalyst for social interactions. The reason of why people share their personal data is to receive emotional support and communicate their identities (Epstein et al., 2015b). However, sharing systems in personal informatics need to be designed to support users in being able to present themselves in a way that they can receive positive social support or encouragement from their appears

since fear of misrepresentation can hinder utilization of social support (Ploderer et al., 2014; Epstein et al., 2015b; Reno and Poole, 2016).

Despite such tremendous development in the field of personal informatics for health promotion, most of these systems are designed for the developed world context. Even existence of randomized clinical trials on utilization of a simple technology such as SMS is largely dominated by countries from developed world (Cole-Lewis and Kershaw, 2010). From HCI point of view, engagement with personalized systems is currently considered to be more personal from data collection to reflection processes. These applications are personal in the essence of ownership of hardware, applications, data stored in applications, and the process of interacting with a system for both data collection, and reflection. The technology interaction context of the existing applications may not be versatile in developing world perspective especially in low income communities of where both sharing in usage of technology and indirect usage through intermediary or proxy users are common (Sambasivan et al., 2010; Kaplan, 2006). HCI in the developing world is a complex relationship between technology, multiple users, indirect stakeholders, observers, and bystanders (Parikh and Ghosh, 2006). An interaction model that assumes one phone/device one person might not always be feasible in such contexts. Also in many contexts, interaction with technology may not be direct; intermediation by another person occurs when the primary user is not capable of using a device entirely on their own (Sambasivan et al., 2010). For users with limited technology literacy or education, direct access to a user interface might not even be feasible (Parikh and Ghosh, 2006); hence intermediation might be the only means for these people to be able to perceive the benefits derived by the proliferation of mobile phones or any other ICTs. While there are people in developing world context whom might lack textual and digital literacy, low-income communities are diverse and often there are some members who have competent skills to operate technology (Sambasivan et al., 2010), and these people may be able to help others to benefit from technology.

The complexity of usage through intermediaries is beyond help on the spot (Sambasivan et al., 2010); hence it cannot be merely solved by endeavours to simplify the user interface. In exploring of why intermediated technology use is beyond help on spot, one has to look at the notion of collectivist societies. In collectivist societies, people engage in tasks in group formation. For instance, India is considered to be a collectivist society of where individuals are prone to group orientation towards tasks (Parikh and Ghosh, 2006). This encourages usage of technology through human intermediaries. In such usage at least two users are involved in one interaction process. There is much more complexity on factors that influence intermediated technology use ; hence it cannot be simply explained by existing interaction models from computer supported collaborative work (Parikh and Ghosh, 2006). Sukumaran et al (2009) emphasizes the importance of

having a better understanding of locally specific interaction models to address cultur-
ally influenced issues in using information technology throughout the developing world.
Intermediated interaction in an example of such interactions that needs to be clearly
understood.

In the context of personal informatics, frequency of usage may vary among different
domains, with the ones targeting physical activity being used more frequent (on daily
basis), while other domains usage is from once a week and beyond (Epstein et al., 2015a).
Therefore, for a context where an end user needs help, motivation to use, is no longer just
for this user but also it has to consider the person helping. This research was particularly
focusing on how a personal health informatics system designed for a personal use can
be adapted in the context where two sets of users are being involved in an interaction
process (the first one being a beneficiary of that technology, meaning a person receiving
help on an interaction task to both collect and self-reflect on their personal data, while
the second one is an intermediary user, a person providing assistance to a beneficiary
user).

The next section highlights the broader view of intermediated technology use in the
context of both developing and developed world communities.

2.4 Intermediated Technology Use

The role of human intermediaries within the context of ICTD (information and com-
munication technology and development) has well been documented as to be the one
beyond that of translators of policies to the ground level (Bailur, 2010). According
to Heeks (1999), cited in Bailur and Masiero (2012), human intermediaries bridge the
gap between what the poor have and what they would need in order to use ICTs. An
example of scenarios of where intermediaries have been of great value is that of public
access venues (PAVs) such as telecentres. Without the presence of these intermediaries
in PAVs, the groups that are excluded from access due to their age, socio-economic sta-
tus, level of education/literacy, gender, disability or caste are more likely to face barriers
in accessing information (Ramírez et al., 2013). Therefore, human infrastructure within
ICTD context plays an instrumental role in facilitating information and communication
access in low income communities (Sambasivan and Smyth, 2010). Literature also points
out that one of the factors that contributed to failure of past PAVs' initiatives is lack of
understanding of position and motivation of intermediaries (Bailur, 2010).

Human factors that affect and shape the outcome of facilitating information and com-
munication access through human intermediaries have been well studied. Bailur (2010)

used structuration theory(Jones and Karsten, 2008) to study intermediaries' role and findings revealed how intermediaries play a liminal role with different stakeholders of PAVs and multimedia centres (i.e. NGO or government, donor agency on one side and community on the other side). Bailur and Masiero (2012) argues that PAVs' intermediaries should not be taken for granted in the space of ICTD because they play a complex position of brokers and translators as they assume multiple identities to different stakeholders of which their roles are constantly negotiated and performed within these multiple constructed networks. Another study is by Ramírez et al. (2013) which investigated how human factors such as empathy and technical skills of infomediaries influence the outcomes of the process of infomediation to users at PAVs.

The ecosystem of utilization of intermediaries in PAVs or other community centres has also been examined through lens of HCI. Focus on HCI has been on engagement of all layers of users involved in intermediated interactions. Parikh and Ghosh (2006)'s study in India provided a taxonomy of intermediated information tasks from HCI perspective; of which different modes of access were distinguished, and each one of them was suggested to have its own design requirements. These modes of access were: (1) cooperative, of whereby several users fairly collaborate without domination by a single or fewer users; (2) dominated interactions, of where users collaborate but they is one or fewer users who dominate others in manipulating user interfaces; (3) intermediated interactions, this whereby the first user manipulates interfaces while the rest of users are just observing what is happening; and (4) indirect interactions, of where one or multiple users are being assisted to interact with a system without being being present or observing while manipulation of user interfaces is taking place. Sukumaran et al. (2009) conducted an experiment that investigated how social prominence of an intermediary versus technology in a computer kiosk affects perceived information characteristics and attitudes towards an interaction by a beneficiary user/secondary user and found out that when the technology was more visible and an intermediary did not monopolize access (situation of social equality), beneficiaries tended to feel more engaged and positive.

Although intermediaries in public access venues are considered as policy implementers on the ground level through working with communities, their position is very complex as they are the bottom of the hierarchy but they are also perceived not to be part of the community; hence they cannot specifically identify with a certain group since their roles are adapted according to circumstances (Bailur, 2010). Motivation of intermediaries in this context of PAVs is negotiated relative to their particular network. A different ethnography study by Sambasivan et al. (2010), explored the dynamics of intermediation beyond public access venues (*i.e in inherent home, or community settings that involve neighbours and family members as intermediaries* –these intermediaries are more embedded to the community as they are considered part of it). Sambasivan et al. (2010)

presented three distinct forms of intermediated interactions: inputting intent into the device in proximate enabling, interpretation of device output in proximate translation, and both input of intent, and interpretation of output in surrogate usage. This study also highlighted factors such as: (1) social mediators of motivation for intermediation such as interpersonal trust or prior social rapport, a give and take economy, social structures (i.e. access constraints due gender, economic status, tendency of reliance on others, etc.), etc.; and (2) design implications to enhance engagement of users (intermediary users, and beneficiary users) such as : reorientation of technology to allow sharing between primary and secondary users for asymmetric engagement; and supporting persistent storage of information for retrieval at later stages by beneficiary users. The study also proposed that measurement of use should go beyond ownership to also consider those who benefit without direct usage.

The concept of informal help in technology use within family and social network settings is not an exclusive phenomenon of only developing world as it is present in developed world as well. Poole et al. (2009) cited in Katule et al. (2016) examined the dynamics of computer help-seeking and giving behaviors in the context of family and social networks settings, their findings indicated that an important factor that encourages help-seeking behaviors is availability of unlimited help provided as a part of a longer-term relationship, while in the case of help-givers, they are motivated by a sense of being accountable to their family members and friends.

In the next subsection it is discussed of how intermediaries have been used in other health behaviour change interventions in the context of developing world and what is the gap from literature.

2.5   Intermediaries in Supporting Health Behaviour Change

In some of the ICTD projects, community health workers (CHWs) have facilitated access to health information on behalf of communities in which direct access to health information resources was not possible. These CHWs have been serving as an effective bridge between communities and government-based resources (Katule et al., 2016). Therefore, in such contexts, CHWs have acted as intermediaries by facilitating access to health information, to less privileged individuals in resource-constrained environments.

One project in India utilized CHWs - referred to as ASHAs (Accredited Social Health Activists) to address barriers in complying to good maternal health practices (Ramachandran et al., 2010a,b).. Most of the ASHAs were women. These ASHAs were empowered with mobile phones that contained persuasive messages that they could use while visiting

their clients. Persuasive messages on the phones gave ASHAs credibility in persuading both pregnant and postnatal women together with their relatives on maternal health issues.

A different project was carried out in Lesotho (Molapo and Marsden, 2013), of where rural health trainers were empowered with a software application for creation of digital training content, voice-over images that can be used by low-literate CHWs to train clients in some villages in Lesotho. While the main objective of these podcasts was for training purposes, upon CHWs showing them to their clients, there were unintentional persuasive effects that motivated these clients to get tested for diseases such as tuberculosis.

A study by Kumar and Anderson (2015) in India used a feminist reflexivity lens to study how patriarchal structures and social conventions constrain women in accessing maternal health information, and how these women leverage help from intermediaries within their communities to navigate their way out. The study further highlighted different groups of intermediaries who facilitate dissemination of information. Examples of these intermediaries include but not limited to mobile shop owners, children and youth, and ASHAs. One interesting finding from that study indicated that even ASHAs became constrained in accessing technology on the process of transferring mobile media to their phones; hence they tended to seek help from their family members. Another observation was on technology access in patriarchal families of where access to cellphones was mostly dominated by men. In such contexts children appeared to have free access to their fathers' devices; hence these children were using the same devices to facilitate their mothers with information access. Vashistha et al. (2016) conducted a fourteen (14) weeks experiment to compare three distribution channels in dissemination of mobile videos on maternal health and these were, mobile shop owners, laptop owners, and ASHAs. Both of the three distribution channels were found not to be very different, however, ASHAs were found to be more effective in distributing videos to the people who where need or demand of such videos.

In the aforementioned projects that utilize CHWs, these CHWs were acting as human access to information that had a persuasive effect. A challenge with utilizing CHWs is that their availability is limited to fewer visits in intervals of weeks or months; hence may not be suitable for a technology such as a personal health informatics of which its beneficiaries may need to engage with it more regularly. Also other forms of distribution and viewing have limitations as it was found in Vashistha et al. (2016)'s study that dissemination decreased over time, therefore, it was suggested an exploration of alternative mechanisms to extrinsically motivate intermediaries and viewers for broader video distribution.

In the context of children and youth within family settings, one may argue that their innate tendency to care for members of their families or communities may be a sufficient motivational factor for sharing health information, however there may be some limitations to that approach considering the fact that a personal health informatics may require frequent engagement, and without intermediaries having an interest in the system, it is not possible to have sustained usage. A study by Epstein et al. (2015a) found that users of personal informatics that target health domains such as physical activity have tendency of using them more frequent (at least once per day) compared to personal informatics targeting other domains. Introducing such a system in an ecosystem of intermediated technology use can introduce the following implication on its utilization; there is a possibility that people who are less familiar with such systems to seek help more often. Dependence on an innate intrinsic motivation of intermediaries alone may hinder availability of such a system to beneficiaries. The outcome of this is that there will be an intermittent usage which may have an impact on self-reflection, therefore, introducing a bottleneck in persuasion. The caveat of relying on natural intrinsic motivation of children to help their parents is also exhibited in a study by Kiesler et al. (2000) about informal help, of where parents reported to be skeptical in seeking help from their children in order to avoid negative experiences (i.e annoying their children because of asking for help more often). This proves that for systems such as personal health informatics of which help may be solicited more often, there is a need to explore on motivation techniques to enhance user experience of intermediaries. In the next section, the discussion is centred on a theoretical foundation on, motivation and user experience strategies that were applied at later stages of this study in order to encourage utilization of a personal health informatics through family intermediaries. This study puts an emphasis on engaging intermediaries to become part of that ecosystem. Motivation is explored through the lens of self-determination theory.

2.6   A Self-Determination Theory Approach to Motivation

Motivation is categorized into intrinsic motivation (i.e. inherently embedded with ones' values and goals), and extrinsic motivation (i.e. doing something because of expecting some external outcome) (Ryan and Deci, 2000a). Therefore, the locus of control is internal to the person in intrinsic motivation while in extrinsic motivation the locus of control is external to the person (Lee et al., 2015).

Self-determination theory (SDT)(Deci and Ryan, 1985a), a well grounded theory of human motivation, is concerned with how individuals develop interest to engage with certain activities that were once considered uninteresting (Ryan and Deci, 2000a). SDT

has two sub-theories namely: (1) cognitive evaluation theory, which focuses on supporting of certain basic psychological needs in order in increase enjoyment of an activity or task; and (2) organismic integration theory (OIT), which focuses on the process of internalization of a regulation of a behaviour through extrinsic motivations. The OIT further discerns extrinsic motivators that can foster intrinsic motivation from extrinsic motivators that can harm intrinsic motivations (Lee et al., 2015; Ryan and Deci, 2000b).

Cognitive evaluation theory suggests that an intrinsically motivated activity is performed out of satisfying some psychological needs, therefore, for an uninteresting activity to become interesting through external rewards, social factors must provide support for the following three basic psychological needs; competence, relatedness, and autonomy (Ryan and Deci, 2000a). Autonomy deals with volition in initiation and regulation of a behaviour. It also emphasizes on the importance of individual's freedom to choose their own identity to represent oneself. Autonomy gives individual freedom to choose when and how they would want to initiate a behaviour. Competence emphasizes the need for individuals to be presented with challenges that give them a chance to sharpen or develop skills that match presented challenges. Challenges should not be too difficult or too easy to accomplish (Zhang, 2008; Colineau and Paris, 2011). This process of providing challenges is appropriate for ones' health psychological development and overall well-being (Zhang, 2008). Competence has a tendency of improving perceived enjoyment provided that there is a guarantee of autonomy (Forde et al., 2015). Therefore, in the absence of autonomy, support for competence may not lead to positive outcome on intrinsic motivation. Relatedness is the desire by individuals to feel a sense of belongingness. This implies people enjoy to be connected to others.

The premise of self-determination theory is that a behaviour that is externally motivated can become internalized (Ryan and Deci, 2000a). Organismic integration theory stipulates that different levels of internalization for self-regulation of uninteresting but important activities to become interesting, of which these levels are classified into four stages namely; (1) external regulation, (2) introjected regulation, (3) identified regulation, and (4) integrated regulation (Ryan and Deci, 2000a). The four distinct levels of internalization are shown on Figure 2.1. In external regulation, individuals self-regulate because of an external outcome such as contingencies of, rewards or punishment. This similar to conditioning of where good or bad behaviours have their respective contingencies of rewards and contingencies of punishment. In introjected regulation, individuals self-regulate as an attempt to raise their self-worth with respect to others; hence regulation is as the result of ego involvement. In identified regulation, individuals put value into an activity; hence they try to self-regulate an activity because they consider it as important probably for achieving a much broader goal; while in integrated regulation,

individuals have fully assimilated the self-regulation to their core values and beliefs. Integrated regulation shares values with intrinsic motivation although it is not intrinsic motivation since its self-regulation is due fulfilment of an external outcome while in intrinsic motivation self-regulation of an activity is as the result of an activity itself being interesting (Ryan and Deci, 2000a). It is possible after doing an externally motivated activity for so long individuals may start to enjoy the activity itself regardless of its external outcome, then at this level the activity has already become intrinsically motivated. The internalization process is governed by social and environmental factors of which individuals function (Lee et al., 2015; Ryan and Deci, 2000b).
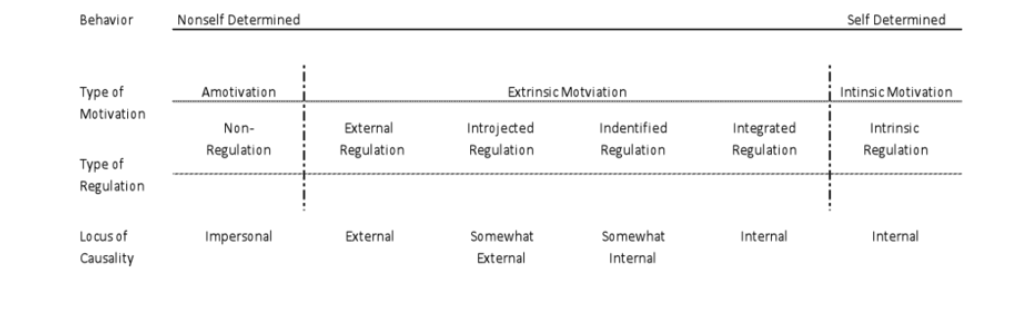
FIGURE 2.1: Organismic Integration Theory (Ryan and Deci, 2000a)

SDT has been used to understand motivation on various activities or behaviours such as; gaming (Ryan et al., 2006), physical activity (Power et al., 2011), tobacco cessation (Williams et al., 2006), energy saving (Webb et al., 2013), etc. This study brings the motivation pull of gamification through the lens of SDT in order to understand how gamification can be used effectively towards encouraging intermediaries to assist their respective beneficiaries in utilization of personal health informatics. In the next section, gamification is discussed from perspective of self-determination theory.

2.7 Self-Determination Theory Support in Gamification

In order to understand why gamification may be important in intrinsic motivation, one has to understand about motivational triggers behind games. Knaving and Björk (2013) framed the concept of games in-line with play and fun of where they conceptualized the terms as follows: (1) *fun* is a rewarding and developmentally appropriate process necessary for survival as it imparts humans with skills, knowledge, and social cohesiveness; (2) *play* is a voluntary engagement to an activity in order to have fun and feel pleasure; and (3) *games* is a formal play that is bounded by rules.

Games have defined goals and immediate feedback on progress towards goals (support for flow) and these are important mediators of optimal experience in play (Knaving

and Björk, 2013). One online survey with (N=429) found that social play, relatedness during game play, and flow were some of the factors that were positively associated with players psychological well-being (Vella et al., 2013). Ryan et al. (2006) investigated motivational pull behind video games using self-determination theory and found that needs for autonomy, competence, and relatedness independently predict enjoyment and future game play. The importance of providing support for the three basic psychological needs has been emphasized by situating the needs into motivational affordances to use ICTs with an objective of fostering motivation in usage of ICT systems (Zhang, 2008).

Nakajima and Lehdonvirta (2013) argue that we should design systems to mimic the techniques used in games to build emotionally engaging persuasive systems. The motivational aspects of gaming have attracted researchers to explore their usage beyond gaming context and this has resulted to the advent of phenomena such as serious games and / or gamification. Gamification is the use of game design elements in non-game context (Deterding et al., 2011). Gamification tends to invoke users' intrinsic motivation through gameful experiences and affordances (Hamari et al., 2014a). Gamification is used outside game context to increase interest on uninteresting but instrumental activities (i.e. physical activity, crowd-sourcing tasks such as image annotation etc.). A systematic review on peer reviewed studies found that gamification provides positive effects and these effects are highly dependent on both the context in which gamification is implemented and the users using it (Hamari et al., 2014b). Extrinsic integrated games have a practical advantage of having patterns that may scale well to different domains while for intrinsically integrated games scalability may be a problem and in practice it is much harder to design an intrinsically integrated game for each domain (Preist and Jones, 2015).

The most popular extrinsic motivators in gamification are points, leader boards, achievement badges, levels, story theme, clear goals, feedback, rewards, progress, and challenge (Hamari et al., 2014b). There are different schools of thought on whether gamification itself is a game or not. Most debates are centred around what a typical game entails (i.e. presence of rules, meta-games, immersion, voluntarism in their adoption, etc.) (Seaborn and Fels, 2015). According to Deterding et al. (2011), users of gamification can socially construct a meaning of whether they perceive gamification as a game or not. The paper further argues what can be experienced in gamification can be termed as a gameful experience with an experiential "flicker" between gameful, playful, and other modes of experience and engagement. This means that users could perceive a gamified tool as a game or they could consider it as a tool that is instrumental for achieving a certain objective. For instance while users use a specific tool to achieve something, there is a possibility of the same people experiencing enjoyment from gameful or playful experiences. Seaborn and Fels (2015) argued that the goal of gamification is different

from games, therefore, it should rather be considered as an act of integrating user experience to an activity outside game context. Knaving and Björk (2013) emphasized that while using gamification, the main activity being promoted should remain salient without being overshadowed by gamification; hence they recommended that designers should strike to balance between preservation of an activity being promoted through gamification and designing for playfulness. The goal of gamification should be to impart knowledge about the main activity being promoted; hence a design strategy should be to support both play and internalization.

Sailer et al. (2013) used self-determination theory to understand the motivational pull of game design elements that can be used in non-game contexts of which their research attempted to provide examples of matching game elements to motivation mechanisms; for instance badges can be used to foster a sense of competence, while a leader board can be used to foster a sense of relatedness as it puts emphasis on collaboration among members of different teams. The use of gamification is influenced by social factors such as social influence, recognition, reciprocal benefit, and network exposure; hence it is important to have a community of people who are committed to the goals that the gamification promotes (Hamari and Koivisto).

Mekler et al. (2013a) conducted a study to evaluate if gamification harms intrinsic motivation. Gamification was added to an crowd image annotation tasks. In that study it was found that gamification can increase engagement but intrinsic motivation didn't change as it was not different from the control group. Depending on how a gamified system has been designed, it can either foster or hinder internalization of regulation that is externally rewarded. One way to foster intrinsic motivation is to ensure that gamification provides an optimal internalization (identified or integrated regulation).

There are some suggestions of which one could use gamification to promote motivation towards optimal internalization. An example of such a suggestion is to to make gamification meaningful. An experiment that examined facilitating contextual factors that can foster internalization of regulation of a behaviour, found out that factors such as framing the task with a meaning (providing a meaningful rationale), being sympathetic about behaver's feeling, and conveying choice fostered integrated regulation (Deci et al., 1994). Nicholson (2012) presents a framework for meaningful gamification that put the user at the centre. The framework was inspired by organismic integration theory explained above, situational relevance and situated motivational affordance, universal design for learning, and player generated content. An example of meaningful gamification, is that of where users are convinced that what they are doing is not just for the sake of playing a game but rather it has a contribution to a good cause. For instance Mekler et al. (2013a) had used points and leaderboard to encourage participants in image

annotation tasks and found that even though gamification didn't harm intrinsic motivation but it had affected the quality of image annotation as participants were focusing on completing more tasks in order to advance in gamification. The same experiment was repeated except this time it had included gamification with meaningful framing of where participants in the meaningful framing were informed that their tags would help improve computerized affective image categorization and hence contributing towards advancement in science. This resulted into better quality tags produced by participants in the meaningful framing condition (Mekler et al., 2013b) compared to participants in gamification without meaningful framing. In the context of this research it was hypothesized that pairing an intermediary and beneficiary that have a good social relationship would intermediaries view it as a good cause as they will be helping people they care about; hence it was anticipated that this framing would make the collaborative gamified system to be perceived as meaningful.

The next section presents utilization of games and gamification in health interventions and what is lacking in literature as far those interventions are concerned with regard to supporting utilization of personal health informatics through intermediary users.

2.8 Games in Personalized Health Interventions

Following the diffusion of video games in many digital devices of where such games are used for entertainment purposes, there is an increasing interest on the potential of such entertaining platforms in utilizing them towards influencing positive changes in health behaviours (King et al., 2013). Traditionally, games were sedentary, but nowadays there are games that require user to exert body movements in order to play a game. Researchers are exploring of how games could be adapted to engage people with personalized interventions targeting healthcare (McCallum, 2012). Games for health include exer-games, games with purpose (serious games), and gamification.

2.8.1 Exergames

Exergames combine exertion (body movements that are beyond sedentary activities) and video games. Exergames may include strength training, balance, and flexibility activities (Oh and Yang, 2010). Exergames increase the amount of energy expended by the body (Graves et al., 2010). Examples of exergames include dance video games i.e. "Dance Dance Revolution" (Lieberman, 2006) or games such as Nintendo Wii Fit (Göbel et al., 2010). There are also exergames that have been designed to be used for outdoors activities. For instance Zombie run is an outdoor exergame that gives end users an

experience of immersion while jogging, and this immersion is achieved through interesting narratives about zombies that appear to chase the runner at a specific point of the story and this makes the runner respond by running much faster in order to avoid being caught by zombies (Southerton, 2013). Using of an exergame should never be confused to exercising (Oh and Yang, 2010). According to (Caspersen et al., 1985, p. 126) cited by Oh and Yang (2010), "*Exercise is doing a physical activity intentionally to improve or maintain physical fitness with a planned, repetitive, and structured format*"; hence playing an exergame entails exerting but it remains a physical activity which may be for entertainment purposes unless an activity of exerting is performed according to the definition of exercise (Oh and Yang, 2010). However, playing an exergame is better than playing a sedentary video game as the former promotes physical activity which is important in increasing energy expenditure. This form of energy expenditure which doesn't fit in a category of exercise is known as *NEAT* – non-exercise activity thermogenesis. NEAT activities such as walking, taking stairs or exergaming (playing exergames) have been found to expend a significant amount of energy (Fujiki et al., 2008). Exergames have application in health settings as they can be used to support rehabilitation (McCallum, 2012). In one study, the use of exergames was compared with traditional methods for physiotherapy of which it was found that exergames performed significantly higher in scores of autonomy, presence, and in functional reach test (Smeddinck et al., 2015). The use of exergames in the aforementioned study consisted of a collection of different games that allowed players to perform bodily movements such as to raise their hands in order to pick apples from a garden and place them to a basket near the ground and this required a player to bend their bodies. In that kind of interaction users have sensors attached to their bodies, and they could perform bodily movements in order to control virtual avatars to perform some tasks on a screen. This is a common way of controlling game characters in many games including the sedentary ones of where it entails' the use of some physical input devices such as game consoles, keyboard or other sensory mechanisms to support players' embodiment of virtual characters or avatars (Berkovsky et al., 2012). So the same approaches are also quite popular in games that are used for health purposes.

It has also been demonstrated that exergames could be accepted by elderly population (Brox et al., 2011). For instance a study by Brauner et al. (2013) developed an exergame that required players to pick fruits and vegetables from a virtual garden using an avatar that represents them on screen of where an interaction with an avatar was through a Microsoft kinetic sensor for detecting body movements and gestures. The aforementioned game was found to be enjoyable by the elderly participants. However, features to support personalization and persistent storage of players' information were not present in that game; hence in such a scenario players cannot resume from previous

state of the game play. In addition to that the only interaction was through bodily movements. There were no complex navigation of which typically in many systems it entails several layers of user interfaces in order to reach the main feature. This implies that navigation to the main gaming interface was less sophisticated; hence may require less cognitive efforts on the side of users in comparison to typical gamified personal health informatics systems which may have several layers of user interfaces before firing an action. It is possible for a user interface of a personalized system to appear sophisticated to users who are not conversant in technology. Older adults group is an example of a demographic group that always face barriers in navigating through user interfaces. A study by Chen et al. (2016) that evaluated an app that implements social incentives to encourage obese and diabetic patients to exercise, found out that technical literacy is a challenge for older patients. Also a review on popular personal apps has revealed that many don't accommodate the needs of older adults (Silva et al., 2014); hence this study emphasizes that one can leverage on existing usage through intermediaries for such populations as this mode of interaction is already prevalent in many low income communities of developing countries. Such an interaction may be possible in collectivist societies (Parikh and Ghosh, 2006). The idea of collectivism in utilization of personal health systems has been emphasized in the dimension of having a community of users that collaborate in management of health information (Colineau and Paris, 2011; Grimes et al., 2009) or different users' of personal systems share health information among each other across social media (Ploderer et al., 2014) but not in the aspect of having one user supporting another user with his or her information needs through a single collaborative user interface. For instance literature reports on exergames and systems that support competition on health self-reflection of where such systems involve parents and children working together (Grimes et al., 2009; Saksono et al., 2015) but not in the context of intermediaries supporting beneficiaries as it appears as if both parents and children are direct users of such systems.

2.8.2 Serious Games in Health

McCallum (2012) defines serious games as games that have been specifically designed to achieve some change in the player i.e. change in knowledge, attitude, physical ability, cognitive ability, health, or mental well-being. Serious games are sometimes referred to as games with purpose of where their intention is to provide experience and emotion with the goal of conveying a meaning at the end (Marsh, 2011). Areas on which serious games can be utilized in personal health include; preventive (exergames), therapeutic (rehabitainment), assessment (self-ranking), educational (medical information), and informatics (personal health records) (McCallum, 2012). As serious games add user

experience to an outside activity (probably uninteresting one), then there is an overlap of goals between serious games and gamification. The two terms are sometimes used synonymously (interchangeably).

There is a rapid increase in the number of gamification-related studies within persuasive technology field (Hamari et al., 2014a). One prevalent utilization of gamification is on promotion physical activity with an objective of promoting NEAT physical activities as they are more omnipresent into people's daily lives compared to volitional sporting activities which are mostly bounded to constraints of location and time (Fujiki et al., 2008). The urgent need to promote non-exercise physical activity is as the result of the prevalence of electronic screens such televisions and computers which has increased the tendency of people becoming more sedentary (Berkovsky et al., 2010). One study (Levine et al., 2006) cited in Fujiki et al. (2008) found out that obese participants were spending more time (164 minutes higher on average) seating compared to lean participants. There is a need for pervasive and ubiquitous computing to support people to become more aware of their lifestyle in order to foster an increase in non-exercise energy expenditure and reducing quantity of calories consumed. This section provides vivid examples of systems that use games/gamification in motivating particular healthily behaviours through self-monitoring. These systems utilize various techniques such as points, avatars, virtual pets, leaderboards, etc. that have already been discussed above.

Lin et al. (2006) developed and evaluated *Fish'n'Steps* system, a computer game which links player's daily footsteps count to the growth and emotional state of a pet fish in a tank. The application was evaluated with a total of nineteen participants in a fourteen-week study. The findings indicated that the game catalysed promotion of exercise and improvement of players' attitudes towards physical activity. However, it was observed that players' enthusiasm had declined towards the end of the second week of using the application mainly due to players becoming accustomed to new routines of healthier patterns of physical activity integrated into their daily lives.

Neat-o-Games (Fujiki et al., 2008), a ubiquitous collection of PDA based games allowed players to accumulate physical activity points which they could use in a race game. In order to accumulate physical activity points, data from a wearable accelerometer are logged through wireless to a PDA and this results into an animated avatar that represents a player, to move forward in a virtual race game. Each player's position in the race corresponds to their current physical activity points. A player with the highest physical activity point leads the race. A player could also decide to use physical activity points to get hints while playing a puzzle solving game called Sudoku. As the result of

using points in Sudoku, a player drops behind in a race game; hence more steps (physical activity point) are required .

Flowie system designed for home settings was a virtual coach used to motivate elderly individuals towards increasing the amount of walking. The system consisted of a frame casing with a touch screen display that shows a flower of which its vitality corresponds to the amount of physical activity captured by using context aware sensors (Albaina et al., 2009). A concept similar to Flowie system is that of UbiFit garden, which generates a garden with flowers of different types that discerned different types of activity such as cardio, walking, housework, etc. (Klasnja et al., 2009). The authors showed the usefulness of living metaphors such garden flowers in communicating information about physical activity level since it makes an interaction experience to be more enjoyable and engaging to end users.

StepCity which is a strategy based game (Walsh and Golbeck, 2014) of which its control depends on accumulated footsteps. In a StepCity game players connect their Fitbit accounts[2] to the game. Players' accumulated steps could be used as currency in the game to buy buildings to place in players' respective cities that produce gold and increase population. Building have side effects, as cheaper building produce more crime while more expensive ones produce none. Players could move through various stages of civilization and also a leaderboard was used link cities by the amount of gold, population and crime. In evaluation there were three experimental conditions; control group (only Fitbit), social interaction experience(app supporting interaction between participants), and StepCity game. The results of evaluating the the game with 50 users who completed the study showed that, newer Fitbit users (n=41) had more steps than those accumulated during the control period (at the beginning before starting to use the game) without statistical significance; however, the overall results were inconclusive.

There are also other studies that used gamification to motivate adolescents or teenagers in behaviours such as frequent monitoring of blood glucose or physical activity (Arteaga, 2010; Cafazzo et al., 2012). Apart from interventions that targeted promotion of physical activity, there are game based apps designed to encourage healthily eating. An example of such an app is *It's Time to Eat* - a mobile game designed to motivate children to practice health eating habits in the course taking care of their virtual pet (Pollak et al., 2010). In their game, players start to select a pet from a range of pets such a worm, dinosaur, dog, tree etc. Then players are required to take care of their selected pets. The first step in taking care of pets is for players to choose names for their respective pets. The process of selection a pet and name giving is meant to give a player a sense of control or autonomy. Caring for pets entails a player feeding it through sending a

---

[2]https://www.fitbit.com/

photo of their breakfast, and then a nutritionist would give it a certain score. Based on the total score, a virtual pet would respond with an emotional state. A healthily breakfast resulted into a pet becoming happy while if the meal is not healthily a pet would become sad. The finding from this study indicated that kids who played the game ate a healthy breakfast more frequently than those who didn't play the game. Another diet based game is called *LunchTime* (Orji et al., 2013a), aimed at educating people to make healthily choices while eating away from home. This application utilized the following persuasive strategies: goal setting, feedback, social influence, and rewarding mechanisms. The game was played by a group of friends visiting a selected restaurant as customers. The game could award points to players according to how healthily the choices of their meals were. A ten days evaluation of LunchTime with six participants (3 males and 3 females) aged between 19 and 40 years of age, indicated that the application facilitated learning and reflection. In addition to that, healthily eating attitude showed improvement at endline in comparison to baseline.

An example of a different use of games is on support for heart rate monitoring, for instance in the case of *Live Pulse Games* (Han et al., 2014, 2015). Live Pulse Games is a collection of games that employ a novel technique to measure users' heart rate in real time by having them play casual games on their mobile phones. In order to gain some in-game control, the player has do some covering of the camera lens with fingertips during the game play. For instance one game within Live Pulse Games is called *City Defender*. In the City Defender game, an end user has to load the anti-aircraft artillery through lens covering actions. The heart rate is computed by detecting changes in blood transparency on users' fingertips.

A different approach to gamification doesn't constitute adding user experience to a targeted health behaviour instead a motivating sedentary game is interlaced with the targeted health behaviour. This approach is based on Premack's principle (Premack, 1959), which suggests using of an event with high probability such as playing a computer game, to motivate an activity with low probability such as doing physical activity. An example of a game that utilized such an approach is a game called *PLAY MATE* (Berkovsky et al., 2012, 2010). The aforementioned game takes advantage of motivation factors of video games by introducing a burst of physical activity during a session of a sedentary game play. *PLAY MATE*, which was an alteration of an open source computer based game called *Neverball* requires players to collect coins in a limited amount of time (Berkovsky et al., 2012). In PLAY MATE, players were allowed to gain in game virtual rewards (extra time) in return for performing a jump in the middle of a session of a sedentary game play. Jumps were detected through a sensory device (built with accelerometer and gyroscope) worn on the waist. The preliminary evaluation of the aforementioned system indicated that skilled players had a tendency of performing less jumps compared to less

skilled players; hence the game was modified to include an adaptive algorithm of where the level of difficult was personalized according to player's completion time of previous levels.

A similar idea that implicitly utilizes Premack's principle (Premack, 1959) is in education settings of where enjoyable game playing was combined with revising for an examination (Preist and Jones, 2015). The approach used F2P (free-to-play) game business model of where users are presented with a full functioning game that is freely available but has an option to do micro-payments in order to either speed up game play (i.e. speed up resource gathering used to advance in technology for combat in a strategy game) or provide access to virtual goods. The aforementioned study had used a strategy of a game similar to clash of the clans to motivate 15-16 years old children towards revision in preparing for a mathematics examination. The option of micro-payment was substituted with virtual currency earned through taking revision tests at any time within the game play. An experiment was conducted to measure the effectiveness of the educational game in comparison to two groups which were control group, and the group that used a quiz generator software. The findings indicated that there was a statistically significant improvement in performance (pre-post scores of the test) among those learners that were assigned to the game condition. Even though the idea was conducted in learning context, one can also adapt the same concept to the context of promotion of health behaviours.

Most of the health based interventions reported on literature are carried out in contexts that are not constrained in resources with exceptions of fewer such as the one that developed an exergame for families in low socio economic areas (Saksono et al., 2015) or another study that used user centred approach in development of mobile game based applications for promotion of physical activity in low socio-economic status youths (Blackman et al., 2016). Literature of utilization of serious games in developing context is scarce and existing studies tend to focus on education (Kam et al., 2008; Botha and Herselman, 2015).

In this research, the focus was in health interventions within contexts of low resource settings of a developing country which may not be the same as a context of low socio economic status in developed countries. The second drawback of those gamified personalized interventions is that they tend to be designed for direct/primary users of technology as consideration is on only direct beneficiaries. In most of these interventions, the person (be an adult or young person) who is a targeted beneficiary of information on the app is expected to be an actual manipulator of user interfaces of such a system. Most of the motivational incentives provided by such systems target direct users who in

most cases are younger and technological literate users. Therefore, none of the aforementioned studies has explored utilization of gamification of where one user facilitates an interaction process while an actual beneficiary remains as an observant or indirect/secondary user. Thus this study aimed to explore how one could implement motivational incentives (affordances) to target a pair that consists of an intermediary user and a beneficiary user. Literature on intermediated technology use has shown that young people within a community may fit well as intermediary users. In addition, young people have an inclination towards playing computer games compared to old ones (Brauner et al., 2013); hence there is an opportunity of leveraging motivation of young people through gamification to foster collaboration between adults and children with the goal of children engaging adults who may be less conversant or less motivated to engage with gamified personal health informatics.

Chapter 3

Study Context

3.1   Obesity

This section describes obesity from the clinical point of view to show the link between obesity and lifestyle. Obesity is as the result of a positive imbalance between energy intake and expenditure such that excess energy is stored in fat cells, which enlarge or increase in number (Steyn et al., 2006). This positive imbalance is due to two factors and these are (1) overeating especially of energy dense diet (food that is either high in fat or sugar), and (2) a sedentary lifestyle. Results of well-conducted randomized control trials have concluded that the two aforementioned factors increase risk of obesity (Swinburn et al., 2004).

This is what will happen if an individual eats energy dense diet. A diet that is high in simple carbohydrates may result into a sharp elevation of postprandial insulin levels which could lead to increased triglyceride storage in the adipose tissue depots. After a spike of insulin level, the body senses that it has consumed all this energy but it doesn't need the whole of it; hence it stores it into fat cells. If many cycles of storage happen it implies there will be an increase in fat depots and if a person doesn't expend enough energy to exceed what is taken in then the fat will remain in depots. As insulin spikes happens it is likely for a person to feel hungry just after not long enough from eating. This is due to an immediate conversion of all the sugar into energy, then the body converts it into fat upon realizing it exceeds the current required energy. After that the fat is stored into depots; hence there is no sugar left in the blood stream, as the result a person may be tempted to keep on eating to compensate for depletion of glucose (Bouchard et al., 1993). This poses a risk of going into many cycles of eating and probably being predisposed to binge eating disorder (Collins and Bentz, 2009). Individuals with binge eating disorders lose self-control of their eating patterns.

Therefore, as a person becomes obese they are predisposed to losing control of their eating pattern and this may worsen their current situation of obesity.

Classification of whether a person is obese or not relies on body mass index (BMI) in most cases. BMI is the ratio of the person's weight in kilograms over their height in meters (m) squared. In some populations, a person is considered obese if their BMI is above 30 kg/m^2 (Steyn et al., 2006) while in other populations the cut off point may be different. But there is controversy on using BMI alone as some people can weigh more and may not necessarily be obese (having extra fat), because the extra weight may be due to having extra muscle, bone or water; hence in addition to BMI, a measure of waist circumference is also recommended to clinically diagnose obesity (Janssen et al., 2004).

The risk of developing a number of obesity-related co-morbidities rises exponentially with increasing BMI over 30 kg/m^2, which is further associated with an increase in the relative risk of premature death, primarily from CVD (De Groot et al., 2000).

3.2   Context Description

This study was conducted with participants from low socio economic neighbourhoods of Cape Town. There were four study sites of which one of them was a diabetic and endocrinology clinic which is frequented by patients from low socio economic areas, while the remaining sites were three low socio economic townships in South Africa.

The rationale for a decision to work with participants from low socio economic neighbourhoods is supported by literature. A review by Dinsa et al. (2012) suggested that in countries with medium human development index of which South Africa is included, groups of low socio economic status also are affected by obesity, and the trend shows that women of low socio economic status are mostly affected compared to women of high social economic status. Some barriers to adoption of healthy life style that are present in low socio economic communities in the west also appear to recur in low socio economic urban communities in Cape Town, South Africa. In studies that have been conducted in developed countries, it has been revealed that in low social economic areas, there is a presence of some environmental factors that may influence behaviour patterns that predispose individuals to obesity. The environment may play a role of both promoting intake of unhealthy food and discouraging of physical activity. Some of those factors could be lack of access to recreational facilities, or poorly designed built environment which lacks roads for pedestrians, lack of public transport that promotes use of private transport. The environments in which people live in are complex and their individual and their combined elements have a marked effect on behaviour and dietary

intake (Swinburn et al., 2004). Food choices can be largely influenced by cultural issues and other factors such as price, portion size, taste, variety, and accessibility of foods (Ali and Crowther, 2009). The environment may also promote obesity by providing more frequent opportunities for consumption of large quantities of food high in fat (Hill and Peters, 1998). These contextual factors that may put individuals at risk of becoming overweight or clinically obese were also somehow present in the context of participants of this research. Many low income neighbourhood in Cape Town are not safe; hence it prevents people from doing simple physical activity such as walking. In addition, the meal outlets in townships sell food that is high in calories. In the contextual enquiry that is reported on the next chapter, majority of the diabetic and obese participants claimed that healthy food in supermarkets is expensive, and in addition they have to eat what the rest of the family eats because they cannot afford to prepare two separate meals. The preliminary study that is reported on the next chapter observed that the notion of healthy food is not quite understood, therefore, the application that was tested in this context helped participants to understand that you can still live a healthy lifestyle by utilizing whatever resources you have. The aim of this research was to explore how to design to support motivation in intermediated use of a personal health informatics in the context of South African low income townships.

The problem of obesity in South Africa is quite alarming. Statistics have shown that almost 60% of South Africans are overweight (Ng et al., 2014). Urbanization or emigration of people from upcountry to cities have been suggested as possible reasons for adoption of unhealthy behaviours as the city lifestyle encourages people to be more sedentary and increase in consumption of caloric dense food (Ali and Crowther, 2009).The populations that live in low socio economic areas are facing a lot of challenges. Most of apartheid policies towards health didn't focus towards these populations and some of the current health and economical concerns are as result of amplifications of apartheid social clusters (Benatar, 2013). Above stated reasons justify why it is crucial to focus on low social economic areas. In addition to health concerns, we have already discussed of how sharing technology and indirect user could hamper utilization of technology in health interventions in the context of low socio ecoonomic areas of developing countries.

Chapter 4

Contextual Enquiry

4.1 Study Description

The purpose of contextual was to elicit preliminary requirements to inform the design of
an early prototype of a personal informatics to be utilized through intermediaries. These
preliminary requirements were generated based on insights garnered from exploration
of: (1) issues related to technology utilization; and (2) barriers to adoption of healthy
behaviours. These insights were generated from data collected in hospital settings with
patients who qualify to be prospective beneficiaries of such a technology in future. The
main objective of this exercise was to gain an understanding of utilization of cellphone
technology among adults obese patients. This study was approved by the respective
institution's ethical review body [1].

I worked together with one research assistant in order to carry out this contextual
enquiry. This work was conducted in between March 2013 and May 2013. We recruited
a convenient sample of diabetic patients at a diabetes and endocrinology clinic of Groote
Schuur Hospital in Cape Town.This is an outpatient clinic which runs on Thursdays and
Fridays.

Participants were approached opportunistically as they waited to see their physicians.
We conducted interviews in one of the vacant consultation rooms. This guaranteed
confidentiality and privacy of participants. The main topics in these semi-structured
interviews were focused around participants' general utilization of mobile phones and
specific usage for health, whether they seek help from intermediaries, and, if so, who
their preferred intermediaries were. In addition we explored their current barriers to
both exercise and adoption of healthy diets.

---

[1]Human Research Ethics Committee of Faculty of Health Sciences at University of Cape Town

We obtained our data from a total of thirty participants. Twenty of the participants were females. Majority of the participants had primary and secondary level education as shown on Figure 4.1. The distribution of participants by ethnicity is shown on Table 4.1 of which all of them were from previously disadvantaged races during apartheid era in South Africa. Majority of these participants were also low income earners (Figure 4.2), this income data was for individuals and not households. Twenty three percent didn't have any income and depended on their family members to sustain themselves. In this group of people with no sustainable income, there was only one young person who was 21 years of age while the remaining participants were above 40 years of age.
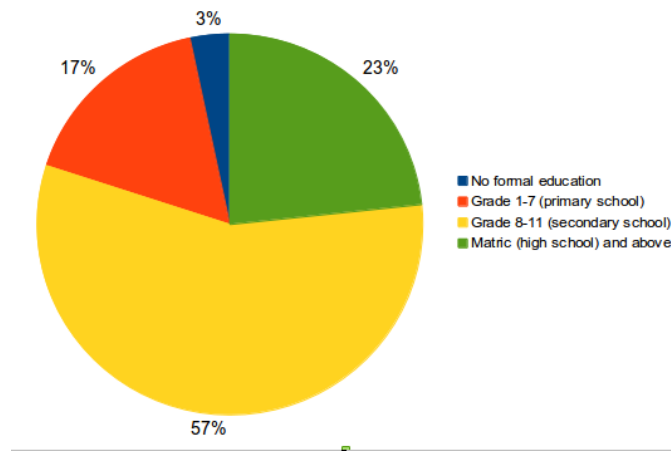
FIGURE 4.1: Participants' income distribution.

TABLE 4.1: Ethnicity of contextual inquiry's participants

Ethnicity	No. of Participants	Percentage
Black African	8	26.67%
Coloured	22	73.33%

Most of the participants were either overweight or obese with an average body mass index (BMI) of 33.36 kg/m^2 (standard deviation of 5.74 kg/m^2). The average age was 53.13 years old (standard deviation of 11.77 years old). Almost 86% (26) were above 40 years of age. This means we were dealing with old participants and hence this group had a tendency of being inexperience or less conversant with technology.

4.2   Data Collection Methods and Analysis

We used a semi structured questionnaire to interview participants. Each participant was interviewed for a period of 20 to 30 minutes. The questionnaire had four groups of
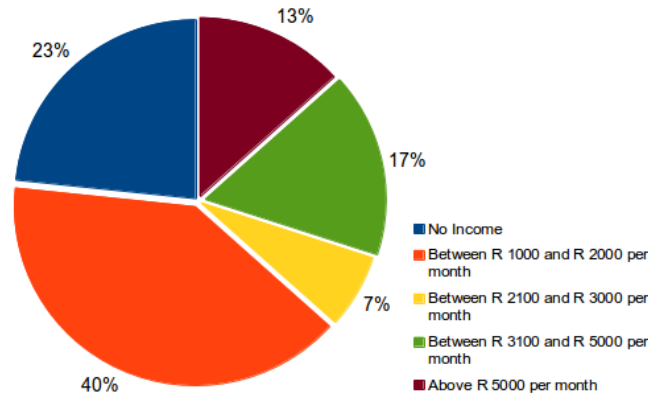
FIGURE 4.2: Participants' income distribution.

questions and these included: demographics; cellphone ownership and utilization; access to information and pedometers; and barriers to diet and physical activity.

I used both descriptive statistics and qualitative approaches to analyse the information obtained from participants' responses. Although our objective was to interview overweight and obese patients only but we included few participants who appeared to be thin but were diabetic. Since diabetes is a lifestyle related disease, we found that it would be interesting to also understand utilization of cellphones, and access to information even to individuals who appear not to be overweight but these individuals may had some input on various issues related technology utilization, and barriers to adoption of healthy behaviours. All the names that are used in presentation of findings are just pseudonyms to protect privacy of participants.

4.3 Findings

4.3.1 Utilization of Cellphones

Twenty nine out of thirty participants owned cellphones. The most used services were SMS and voice with at least 80% of the participants using each of the two services. It was found that at least 60% of the phones owned by participants were smart-phones (Figure 4.3), but utilization of functionality/services that are supported in smart-phones appeared to be lower relative to voice and SMS (Figure 4.4). Utilization of smart-phone supported services appeared to decrease with age. Utilization of Whatsapp appeared to be higher compared to other services that are specific to smart-phones. What led to adoption of Whatsapp is that participants were influenced by family members and friends who were already in Whatsapp. These influencers suggested Whatsapp as to be

cheaper than SMS. For instance one male participant aged 47 years of age heard that Whatsapp was cheap for communication, and his son helped him on loading it into his phone. Therefore, in this context, social influence played a role in adoption of some smart-phone supported services. There is a positive correlation between social influence and adoption of high-tech innovations (Vannoy and Palvia, 2010).
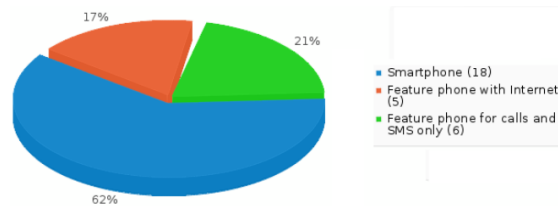
FIGURE 4.3: Participants' phones types.
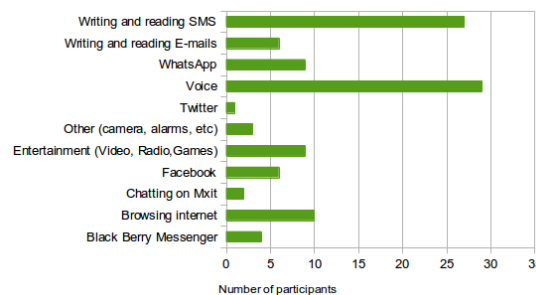
FIGURE 4.4: Participants' phones types.

4.3.2 Help Seeking in Utilization of Cellphones

There were several scenarios of informal help seeking in utilization of cellphones as highlighted on Table 4.2. Majority of the participants had solicited informal help from other people before, in tasks such as: (1) to configure services/apps on their phones (e.g. Whatsapp, Facebook); (2) habituation of skills required for utilization of various functionality (e.g. a phone book of a new or unfamiliar cellphone, Whatsapp); and (3) to interact with certain features such as SMS, Internet browsers, and etc.

There was a variation in the degree of help-seeking and it was determined by how often participants wanted to execute unfamiliar tasks. Tasks such as configuration of services and apps or teaching of individuals had rare occurrences as they only happened when participants had encountered a new application or device and they don't know how to make it functional.

TABLE 4.2: Scenarios of intermediated interactions

No.	Scenario
1	She is being helped to read SMSs by her *daughter*, but she could do it on her own when the daughter is not around.
2	He doesn't know how to reply back to an SMS. So his *grandson* always helps him with that.
3	Her *children* or *work colleagues* could help her to read SMS written in English that are received through her feature phone. She also mentioned that her two children were skilled in operating cellphone more than her and one of them had a Black Berry smart-phone.
4	He can take photos using his mobile phone's camera but he doesn't know how to save those photos on a memory card. His *son* helps him with that once in a while. But, also his son helped him in loading Whatsapp on the phone.
5	Her *children* have taught her on how to use Whatsapp, take video etc. Now she is learning on how to record sound, set reminders on the phone for insulin and medication.
6	The *son* would help her to interact with USSD service for checking loyalty points on MTN. MTN is a mobile communication service provider operating in many African countries.
7	She was taught her *son* on how to access a phone-book when composing SMS using her new phone.
8	She receives assistance from her *helper* when she wants to send messages to her children.
9	She was once helped to do set-up her new phone at a cellphone shop. She was also taught on how to operate BBM by her *grandson*.
10	He was once taught on how operate Whatsapp by his *niece*.
11	Her *son* and *grandson* have once helped to configure Whatsapp and Facebook on her phone. They have also taught her on how to use those two web services. In addition, she also asks the son to search for certain health information on the Internet, and once the search is done the the son would pass the phone to her to view that information. This happens once in a month.
12	Her *son* and *grandson* always teach her on how to use various functionalities like games etc., but she is not so much keen on operating those functionalities. She also admitted that her son and grandson are so much interested with their mobile phones and they spend a lot of time playing using phones something that she doesn't understand.
13	This participant didn't own a cellphone. She had no formal education and she was unfamiliar with how to operate a cellphone. Her son receives SMS directed to her and reads it aloud for her or translates an SMS to verbal communication. Also, the son receives phone calls and hands over the phone to her when the person on the other side of the line wants to speak to her.

4.3.3 Selection of Help Givers

Participants chose trusted individuals to act as their help givers, typically their children and grandchildren or, less often, children of relatives, family friends, or someone at a cellphone shop. Preference on who is likely to be solicited to assist favours family members. Help givers are selected based on the merit of skills/competence, and interpersonal trust based on a social relationship, and past experience of help seekers on specific help givers.

Interpersonal trust

Interpersonal trust in this context means that whether help-seekers may feel comfortable to seek help from specific people or not. Privacy and existing relationship between a help-seeker and help-giver were first concerns when deciding of who should be asked for help. In additional to that, there was also trust on whether a helper giver may be willing to deliver when solicited for help and this was influenced by experiences in past attempts to seek help. Experiences on past attempt to solicit help refers to help-seekers' positive and negative experiences as an outcome of seeking help. These experiences shaped perceptions of some of the participants towards seeking help with cellphone or any other technology. For instance, one female participant aged 67 years old reported that her daughter helped her once but she had no patience. A male participant aged 47 years of age mentioned that he would like to be assisted on using several services such as MMS, but he thinks that young people may not be having patience to help. Such negative experiences can hinder future help-seeking behaviours from specific help givers. This resonates with the following finding by Kiesler et al. (2000), parents may be hesitant to seek informal help from their children after encountering negative experiences.

Help-givers' Competence

In additional to interpersonal trust, the decision of who should be solicited for help was also influenced by help-seekers' level of trust on skills possessed by help-givers. Participants had confidence on competence of their children in using cellphones. Several participants sees their children as having technical know how skills in using cellphones. For instance one 31 years old female participant mentioned that her five years old son knows how to navigate through her whole phone and use it more than what she can do. Another female participant aged 56 years of age explained how children are eager to teach her various things on a cellphone but she is not so keen in engaging to cellphones like they way her son and grandson do. A forty seven years of age male participant

also mentioned that young people in their families are more skilled in cellphone than old people. Participants reported that their kids were borrowing their phones to do other tasks and this demonstrated that their kids had better skills with technology. Scenarios of sharing are presented on Table 4.3 below.

TABLE 4.3: Scenarios of sharing of cellphones between participants and their children

No.	Scenario
1	"Zandile", a 47 years old female participant, mentioned that her 16 years old son could borrow her phone to use MXit. But herself she is not using anything else on the phone apart from calls and SMS. She also mentioned that she is not so much interested with technology. For example she has internet at work, but she is not really using it.
2	"Buyisiwe", a 31 years old female participant narrated an experience about her five years old son who uses her smart-phone to listen to music. But she has to lock it while he is listening, because it happened at one point that the son deleted almost everything on the phone.
3	"Celine', a 48 years old female participant lends her phone to her daughter who uses it for normal Internet browsing and Facebook. Celine owned an advanced feature phone enabled with Internet but she was not using internet on the phone.

In other scenarios participants mentioned that their kids borrow their phones to search for information related to school assignments. These examples demonstrate the level of skills that potential help-givers can have. Trust on skills possessed by help-givers has been found to be very important to individuals seeking help in the ICTD and HCI contexts. Ramírez et al. (2013) suggested that empathy and technical skills of infomediaries influence the outcomes of the process of infomediation to users at public access venues. Another study that examined motivations for informal support in utilization of computers at home found out that skills of help-givers to be one of the factors that influence help-seekers to solicit help from specific people (Poole et al., 2009).

4.3.4 Access to Health Information and Self-Monitoring Support

We had collected information about access to health information and self-monitoring support among the participants. Informational support in which most the participants relied on is that one provided through face to face meetings with doctors or dieticians during hospital visits. Normal hospital visits are scheduled in intervals of every 3 or six months. But they do visit the hospital only two or three times in a year. In addition to face to face information, patients normally receive paper sheets with information that provide guidance on how to eat healthy. These paper sheets are normally received when patients attend clinic for the first time after being diagnosed with diabetes. Most patients

we interviewed were type 2 diabetic and overweight. Doctors and nurses encourage them to eat healthy and exercise.

Majority of the participant lacked informational support beyond hospital settings that could provide guidance in eating healthy and exercising. Very few participants had used cellphone services as means of querying or receiving information related to health. Only six participant had used internet to search for health information, while only one participant had used a cellphone app for health. Also only two participants had used SMS while only one had used voice to look for health information. Table 4.4 shows some of the scenarios of where participants had used ICTs in relation to learning about issues concerning their health.

TABLE 4.4: Participants' usage of ICT to fullfil health information needs

No.	Scenario
1	"Anitha", a female participant aged 56 years old, would send SMSs to her son while he is at his workplace. This SMS is usually a request to check for certain health information on the internet and the son could print for all the material related to that information that was requested. She also follows Dr Oz program on TV about health stuff. If she misses she would go to the Internet and visit the programme's website
3	"Jane", a female participant aged 36 years old, had an app on her phone for giving health tips. She downloaded that app from the Internet.
4	"Maria", a female participant aged 57 years old mentioned that she uses Facebook. She has three diabetic friends and they share diet concerns, recipes, and discuss diabetic specific issues that they experience . They don't discuss about exercise. She sometimes searches on Google about medications especially when she starts using new medications. She uses Google to get more information on the things her doctor advises on.
5	"Evelyn", a female participant aged 63 years old, subscribes to health websites to receive emails with health tips and information. She sometimes calls a dietician to ask about certain diet information.

Self-monitoring of blood glucose seemed to be common among the participants because many of them were diabetic. Self-monitoring of other health parameters such as diet and physical activity seemed not to be done by many participants. Out of thirty participants we interviewed, only two participants had used a pedometer before. One participant reportedly to use a gym bicycle with a meter that can show distance cycled but she has abandoned using it. Only eight participants reported that they have used a diary before to record the food they have eaten. But this recording is not consistent. Some have stopped doing it although they claim that when they visit hospital, sisters (nurses) always remind them to record foods they have eaten. This food recording is mainly for controlling the levels of blood glucose. For instance, one participant mentioned that she has a note of where she records the blood glucose before she eats and the blood glucose

after she has eaten. So she records what she has eaten and the blood glucose levels before and after meals. But overweight and obese diabetic patients are also encouraged to lose weight. Because losing weight has an advantage of lowering levels of blood glucose. And the only way to lose weight is to follow the recommended diet and become more physically active.

4.3.5 Barriers to Adoption of Healthy Behaviours

The research teams also examined on barriers to adoption of healthy behaviours i.e. healthy diet and exercises.

On barriers towards adoption of healthy diet, 76% of the participants mentioned that the recommended healthy food is always expensive. For instance fat free foods are much more expensive compared to full fat foods. One participant associated eating of certain food to cultural upbringing. She explained that Muslims in Cape Town often have very high fat and high sugar content foods such samosas. One of the comments that appeared to be common to many participants is that; it is difficult to have a budget for separate meals within the family, because diabetic members always have their diet food which seems not be preferred by the rest of the family. So diabetic members might end up eating what the rest of the family eats. They do try to have diet foods by it is not always manageable. But one participant who seemed to be highly motivated disagreed with that argument and said most people lack an understanding of what carbohydrate means. She further mentioned that, education about diet should be contextualized to terms that people are already familiar with. She said most people don't understand what is said by dieticians because it is not communicated in the context they understand. For example the concept of carbohydrates is not well comprehended by many people. But if the topic is well explained using what is already familiar to patients, then they are more likely to comprehend it.

On the question of perceived barriers to physical activity, nine(9) participants mentioned that lack of time to do physical activity because of a busy schedule contributes to less exercising. This is supported by some remarks shared by participants on Table 4.5. Seven participants mentioned that lack of areas to walk around is one of the perceived barriers to physical activity. The most common comment given out to support this argument was that, most of the areas where they live are not safe for somebody to be out walking all the time (Table 4.6). Most of these areas have high rates of crime.

But despite the claim of lack of both time and areas to exercise these participants mentioned that they been active when doing their daily errands (Table 4.7).

TABLE 4.5: Excerpts on observation of common participants' remarks on association between being less active and busy schedules

Participants	Remarks
1	She goes to work very early in the morning and comeback late at night.
2	Difficult to manage work and household.
3	She goes to work at 4.00 AM and come back at 7.00 PM. She works for 6 days in a week.
4	She looks after the family. She takes her sisters child to school, also she does the cooking. She does a lot of house work. So it is difficult to have a planned series of physical activity.
5	Difficult to balance between planned session for physical activity and manage both work and household at the same time.
6	Busy with house work at home.

TABLE 4.6: Excerpts on observation of participants' remarks on safety concerns on areas to do walking or running

Participants	Remarks
1	The neighbourhood is not safe to wonder around.
2	It is not safe in her area. She doesn't like to be outside most of the time.
3	It is unsafe at night and early morning.
4	The area where she stays is not safe to walk around.
5	Not safe to walk alone. She prefers to walk through houses.

TABLE 4.7: Excerpts on observation of participants' remarks regarding physical activities that were part of their daily lives' routines

Participants	Remarks
1	She walks from home to visit relatives and friends.
2	He only walks when he goes to church.
3	She walks to from her home to a bus station everyday and walks a lot at her work place, so it would be great for her to have something to keep track of how much exercise she gets. She wants to be more active but works 7 days a week.
4	She exercises in a group of people for three times a week and she now feels much healthier. They have a "biggest loser" competition going at the moment. She would like to have a pedometer to keep a better track of her activity.
5	She walks only when she has to. She only walks up and down in kitchen. She has a treadmill, but she doesn't use it.

4.4 Contextual Design Insights

These are some of the design insights that were uncovered from the aforementioned findings. In this context, majority of the participants were not utilizing ICTs in self-management of their health as they relied only on paper diaries. The only parameter that was being monitored by majority of the participants was blood glucose since all participants were diabetic. Blood glucose is usually controlled through many factors such as diet, exercise, and medication. Type 2 diabetes is linked to obesity and its self-management is mostly through diet and exercise. The process of self-management can be very cumbersome if it is done using pen and paper and this may reduce compliance (Mattila et al., 2008). A paper diary may not be as effective as an electronic diary when it comes into navigating across behaviour patterns for the purpose of self-reflection. Therefore, personal health apps may be important in supporting self-management of health. However, these personal health apps may not be very useful in this context considering the fact that majority of the participants have limited skills in operating technology. The findings above indicate that some participants with limited skills seek help from people with skills. But this approach has its limitations as it relies on existing intrinsic motivation of help givers. Long term usage is crucial for compliance (Mattila et al., 2008), but one cannot achieve this long term usage in the context where a technology needs to be utilized through help givers while most technologies were not designed to anticipate utilization through help givers as part of the usage ecosystem. As it has been advocated that novel approaches such as ICTs in lifestyle modifications may facilitate moving of management of lifestyle-related chronic conditions from healthcare system to citizen-centric health promotion and disease prevention interventions (Korhonen et al., 2010); hence it is important for one to think of how we can design technologies that can scale to demographics that are not well-considered in traditional interface design.

There are several decisions that were crucial to the design of the first prototype. Since participants reported to have activities related to NEAT (non-exercise activity thermogenesis) in their daily life, then the first decision was based on the idea to promote NEAT since they have proved to be beneficial in improving well-being. The second consideration was about promoting of health eating habits using a metaphor that was already used by dietitians. In order to educate patients, dietitians used a meal chart to reflect how a plate with a health meal looks like. The third design decision was on how to design motivational affordance to support collaboration between help seekers and help-givers. This was inspired by the finding about sharing of phones between adults and kids. The finding indicated that kids borrow phones from their parents because they are motivated with specific things on the phone. Some of those things were social media, games, music, etc.. Therefore, if one could design a system that afford specific

motivational affordances that address needs of kids and integrate those affordances with self-monitoring of behaviours of adults, then it is possible to enhance motivation of kids to help their parents with self-monitoring tasks. With the guidance of self-determination theory, and techniques that have been used in the previous studies that utilized gamification (described on the *Literature Review* chapter), a prototype was developed. The iterations of prototype development and subsequent evaluations are discussed in the next chapters.

Chapter 5

Prototype I

5.1 Development of the Prototype

The initial task was to develop the first version of the application prototype. The prototype had features that allow monitoring of physical activity and diet of an individual. The manipulation of user interfaces of the app was specifically targeted to help givers/intermediary users. The prototype was designed to encourage help-givers and help-seekers to work together in a pair. To make the act of helping to be perceived as more meaningful, the first message on the app emphasized that the intermediary users were helping someone close to them to manage their wellness. To motivate ongoing use, the app had included gamification features of where each pair could be awarded points, badges, nice looking gardens and fish tanks. In addition to the aforementioned features, within each pair's garden and fish tank, there was a Facebook social plug-in that could allow users from different teams/pairs to comment on or like each other. Facebook groups were also utilized to give feedback or remind users to engage with the application. Ideally, the information flow on the system is as presented on Figure 5.1. A web app was developed using a combination of several web technologies such as HTML, JQuery, JavaScript, and CSS on the client side while the server side was implemented using Django Python framework. Sample screen-shots of the prototype are shown on Figure 5.2. Authentication was done through Facebook accounts of intermediary users. This prototype aimed at encouraging increase in physical activity and decrease of sedentary behaviours through informing individuals (help-seekers) of their current behaviour trends. In addition, also individuals could monitor whether they are eating healthy or not. Some visualization techniques that are similar to this have been previously used in systems that were designed for direct users such as "Fish'n'Steps"(Lin et al., 2006), "Ubifit"(Klasnja et al., 2009), and "Few Touch Application"(Årsand et al., 2010). The idea of using a plate for

showing distribution of meals is mimicking a practice used by dietitians of where the amount of each food group that needs to be consumed is presented as a bisector of a pie chart.
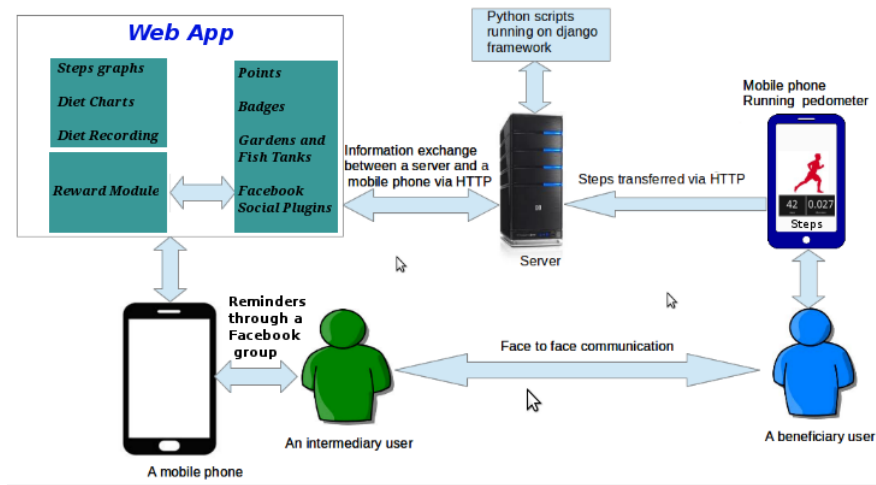
FIGURE 5.1: Information flow in the first prototype.

FIGURE 5.2: Sample screen-shots of the first prototype

5.2 Prototype Evaluation

In order to evaluate the prototype, I recruited participants through an NGO based in Cape Town called "***Mamelani Projects***". This NGO carries out outreach programs

on health education in less privileged communities. Mamelani trains women on issues of HIV/AIDS, nutrition, and gender equality.

The NGO helped to recruit participants among people who were part of their trainings in Philippi township. Criteria for recruitment were as follows: (1) participants aged 35 or above and (2) participants must have an intermediary person willing to work with them. The NGO identified the targeted participants that met the inclusion criteria. A total of six adult participants were recruited of which both were women above middle age (>= 35 years of age). Each one of the adults brought one intermediary to form a pair. Three intermediaries were girls in between 19-23 years of age. The remaining three intermediaries were boys aged between 14 and 19 years of age.

Participants were informed of their rights. Participants were also informed of which of their information will be collected by the study. Both adults and their respective intermediaries signed consent forms except for intermediaries who were minors, these signed assent forms that were approved by their respective parents/guardians.

The next step entailed training of intermediaries on how to use the app. The application was deployed to the field from the end of October 2014 to beginning of December 2014. In order to control the application environment, and limit potential complications from deploying the intervention on multiple platforms, each pair of participants was given one Android phone (Samsung GT-S5300) running the pedometer app. Participants were required to utilize the web application hosted at University of Cape Town by using a web browser built into their phones. In order to retain participants in the study each intermediary participant and each beneficiary participant who remained as part of the study received ZAR30 (ŨS\$3) worth of airtime every week for the duration of the study. I collected qualitative feedback in the middle and at the end of the study. All the names used in qualitative feedback are just pseudonyms to protect identity of participants.

5.3 Findings

Observations and qualitative feedbacks from the six cases/pairs are presented below. The first three pairs consisted of parents working their children while the remaining three pairs it was just an adult working with either a close or distant relative in each pair.

Pair 1: Mother and Son

This pair consisted of a boy aged 17 years of age working with his mother. The boy is referred here with the name "**Jabulani**" and his mother is referred with the name "**Nandipha**". Jabulani lived with his mother and other siblings. He appeared to be passionate in engaging with a cellphone. He described the intimate relationship he had with his cellphone.

> *"There is a time I lost my cellphone. It was like the end of the world to me because I didn't have anything to play with"*

> —*Jabulani*

The excerpt above shows that a cellphone could be a source of intrinsic motivation for young users in this context.

He mentioned that he felt happy helping his mother. He also articulated the reason for helping his mother as that he felt it was his duty since the mother took care of him when he was growing up.

> *"I feel happy when I am helping her because she helping me when I was growing up so it is my turn to help her"*

> —*Jabulani*

Nandipha also felt very happy being helped by her son and she mentioned that she thinks her son is very brilliant more than her in technology and she gets to know things because of him.

Jabulani and Nandipha were the first one to engage with the app for at least three different days. All of a sudden their use stopped. When I asked Jabulani together with his mother of challenges that might have prevented them from using the app, their responses indicated that were more conscious about airtime as it was one of the reasons of why they didn't login more often. So there were times where they ran out of time. They thought having more data bundles might solve the problem. Another reason for why they didn't use the app more often is associated with lack of competitions from other pairs and also they had accomplished the highest challenge within few days. In the first few days they were so curious about attaining the highest badge. Jabulani claimed that her mother was walking up and down so that they reach that goal. Jabulani discussed with his mother that they must reach that goal in a week. They managed to reach the goal and there was no more boundary to break.

Badges were one source of motivation to this pair. Jabulani felt motivated by the badges and he was persuading his mother to work harder so that they reach the highest badge which was Queen/King.

> *"We talked me and my mum that we must not reach only for today but for the whole week. That was our goal to reach the queen and the king for the whole week. I remember a day that was the best day. My mum woke up very early to walk around, to go to Philippi Makasikava [A location within the neighbourhood] just to reach that goal]"*

> —***Jabulani***

Also Jabulani noticed something on the scoreboard. He and his mother were there leading. Another team (Pair 3) was in the second position. The third position was held by Pair 4. Then after few days Jabulani noticed that Pair 4 moved from a third position to a second position. So Jabulani told his mother that "we must not drop down because they (Pair 4) are going to reach us". I that context competition with others was a source of motivation for Jabulani. Although Jabulani was helping his mother but he thought like the ownership of the winning process as theirs because he used the word "We" all the time to imply that he felt that he was part of that process. Additionally, Jabulani enjoyed information displayed by a botanical garden and a fish bowl. He explained why he was so interested in such abstract visualizations. When he was growing up he used to watch cartoons. So when he sees those pictures of trees and fish he feels he is part of that process of making those images/cartoons. So drawing fish and trees through their team's performance motivates him more and he tells his mother that they must have more fish in the bowl. Also the idea of fish in the bowl motivated Nandipha to walk more. She mentioned that she doesn't like to see her bowl empty without any fish, so she tries to walk more steps as she can. These ideas of abstract visualization such as fish bowls/tanks and garden have been previously used in system that involve only one user on interaction with user interfaces (Klasnja et al., 2009; Lin et al., 2006), the only difference in this context is that, the same ideas were extended and tested with two users who are collaborating to attain one objective.

Pair 2: Mother and Son

"**Dumisani**" was a 14 years of age who lived with his mother, "**Kholiwe**". Dumisani was acting as an intermediary for Kholiwe. Dumisani and Kholiwe used the system for only the first three days and they dropped out. On responding to the question of why was it the case, Kholiwe mentioned that it was the inability to access the system every time they tried out. The web page was always giving them time-outs and this

discourages them from trying. But it was also observed that Dumisani was not very familiar with Facebook authentication as he didn't have an account before. I created one account for him of which it wasn't very helpful. The decision in using Facebook authentication was based on an assumption that all intermediaries may have Facebook accounts which was no the case. However, despite technical challenges this pair also showed enthusiasm in using the app.

Pair 3: Mother and Daughter

"**Zama**" was a 20 years of age who was supposed to act as intermediary for her mother, "**Fikile**". Since the daughter appeared to be interested to help her mother, then one would think that intermediation is possible. Unfortunately, the two lived in different houses and they never used the system at all. Their contact to discuss issues about the system was limited as Zama was raising a toddler at that time. In addition, Fikile appeared to had some expertise in using technology as she already was using Facebook, therefore she was interested to learn how to operate the system on her own because of the situation of her daughter. However, the system had been set up only to allow Facebook account for Zama.

Pair 4: Close Relatives

"**Lindiwe**" was a young girl in her early twenties. Lindiwe was acting as an intermediary for her auntie "**Nceba**" but they never lived together in the same house. The pair had not been interacting with the application at all. When I interviewed Nceba of why they were not using the app, her response was that she doesn't know how to operate it on her own and her intermediary seems not to be around most of the time. She is curious to access the information but her intermediary seemed not to be cooperative. So she suggested to bring someone else who was also a close relative.

Pair 5: Close Relatives

"**Neliswa**" was a girl aged 23 years of age. Neliswa was acting as an intermediary for her auntie "**Nkosazana**" but they lived together in the same house. The pair had not been interacting with the application at all. I never had a chance to interact with this pair since they were not available. But from a personal observation during recruitment, Neliswa appeared to be less interested in the intervention even though she signed the consent form to participate.

Pair 6: Distant Relatives

"**Nkululeko**" was a boy aged 19 years of age. He was acting as an intermediary for her distant relative, "**Noluthando**. Nkululeko and Noluthando didn't live so close to each other but they did see each other more often. System logs showed that this team had not been engaging with the application. I interviewed both of them to find why that was the case. Nkululeko pointed out number of things. The first one was that he tried to access the application a couple of times but he was unable to proceed after login. He was using his personal phone. I checked his personal phone and I discovered that his web browser was the problem. He had never tried to do it using the experimental phone that was in possession of Noluthando. He had ne We tried together and it was okay on the other phone. But in addition to phone's problems he claimed to be busy with school. Despite him being busy, and his phone not being able to support the application, the absence of things like reciprocal benefits and a close social relationship with the beneficiary, might be the cause for his low intrinsic motivation in engaging. The previous user, Jabulani had a problem of accessing the application using his personal phone but he made an effort to access using the phone given to his mother. So the closeness/bond of the two sets users might be the base for the network effect to happen.

5.3.1   Discussion

Only two pairs of users engaged with the system for more than two days. Both of these two pairs consisted of a beneficiary and an intermediary living in the same house. These pairs consisted of mothers working with their sons. One of these two pairs was very motivated and enthusiastic about the system. But after some time they also got bored because they were not getting any competition from other teams and they had attained all the challenges within a short period of time. In a third pair, a girl was working with her mother but they were not living together so it was difficult for her to commit to the application. Intermediaries from the remaining two pairs showed little enthusiasm in the project. There were three hypotheses for this lack of enthusiasm to engage with the system and these were: (1) due to lack of motivation to engage with the system; (2) lack of a prior social relationship between the two users within each pair; and (3) Low frequency of interactions between the two users within a pair due to distance.

There was an indication that a prior social relationship is instrumental for intermediaries to perceive value in the act of helping their beneficiary users. In this case the interaction became more meaningful. It also becomes easier for the two users within a pair to negotiate for interaction. For three pairs that consisted of mother/son or mother/daughter there was a tendency for the two users to show the eagerness of working

together. For three pairs where members of a pair didn't have a parent/child relationship, intermediaries showed little enthusiasm in the intervention. Another advantage of a prior social relationship comes to sharing of phones. It was observed that it was easier for an experimental phone to move from a beneficiary to an intermediary when a parent and child were involved in a pair. There was a form of trust that existed between the two users with a prior social relationship. In addition, intermediaries had more authority when they were helping a person who was close to them. If a pair with a prior social relationship needed to interact with the app, then the frequency of these interactions depended on proximity between the two users. For cases where they cohabited or lived nearby it increased the chances of them meeting. For instance, "**Zama**", an intermediary participant aged 20 years old was working with her mother. The challenge with this pair is that they didn't cohabit and Zama had a toddler hence this lowered her ability to participate in the intervention.

Prior social relationship also worked in parallel with the presence of interest to use the app/gamified features. A combination two factors played a some role in encouraging the two users within a pair to collaborate when they met. For instance , in the case of of Jabulani and Nandipha (mother and son), they discussed about strategies to win against other pairs. Although Jabulani was helping his mother but he thought like the ownership of the winning process is theirs because he used the word "We" all the time to imply that he felt that he was part of that process. In addition, if intermediaries are motivated they can become persuaders of beneficiaries that they have a prior social relationship with as it can be seen on Jabulani who encouraged his mother to walk more steps.

There were some drawbacks in utilization of this prototype. From participants' perspective , intermittent internet connectivity, insufficient airtime, less motivated intermediaries, and lack of competition/challenges with others in the gamified system were the key issues mentioned. Other factors include how often the two user meet (Whether they cohabit or they meet more often), and reminders were not timely. I had very high expectations that Facebook reminders will work for this community. An assumption was that every intermediary is probably using Facebook. Actually this was not the case. There were some intermediaries who had never engaged with Facebook before. And the ones who had engaged with Facebook were not doing it so often as I anticipated. For instance "Jabulani" had never used Facebook before. "Jabulani" was only engaging with Facebook at most twice in a week. Therefore, Facebook might not be an on time-platform for delivery of reminders or any messages to intermediaries in this context. Findings from this informative evaluation led to another iteration in the design. It also informed the manner in which evaluations in chapters 6 and 7 were conducted.

Chapter 6

Prototype II

6.1 Prototype Development Iteration II

I started the next iteration of prototype development that aimed to improve the first prototype described in the chapter 5. In the second prototype the emphasis was more on improving support for the three psychological needs from self-determination theory (Ryan and Deci, 2000b) which are relatedness, competence, and autonomy. I substituted Facebook social plugins with features that could allow users to directly comment on or like each other. Facebook social plugins failed to integrate seamlessly with the app since the network signal was a bit poor in the area where I conducted experiments, therefore users failed to load them into the app. In addition, the system comprised SMS reminders and feedbacks instead of Facebook based reminders. The new system (Figure 6.1) had the following features of which most of them were improvements from the previous prototype:

1. Recording of meals consumed by a beneficiary user.

2. A pedometer for detection of steps walked by beneficiary user.

3. Pie charts that show summaries of food groups consumed by a beneficiary user.

4. Bar charts that show steps walked by a beneficiary user (daily intervals, 7 days intervals, and, weeks of a month intervals).

5. Avatars that can be changed in order to increase autonomy of intermediary users.

6. Badges that can be earned through a combination of steps walked by a beneficiary participant and the number of days they app has been utilized by a pair of users. In the previous prototype it was easier to jump from the lowest badge to the highest

without passing through intermediate badges as longer as a pair had enough clicks. Therefore, to move to a higher badge in this second prototype a pair was required to use an app for a certain number of days and then couldn't by [ass any badge as the process was incremental. To reach the highest badges pairs were required to pass through all the badges in between in different days, and also to meet requirements for the King/Queen badge which were at least an average of ten thousand (10000) steps walked by a beneficiary user in a day, and at least 18 days of usage activity detected from the app.

7. Score board/ leader board of which points were earned by averaging between points scored from usage (i.e each day of usage resulted into 1000 points earned) and points earned as the result of beneficiary's average number of steps walked (i.e. if the average is n steps/day then the number of points accumulated is "n")

8. Botanical gardens that consisted of trees and flowers. Trees on the garden grows proportional with badges while flowers grows proportionally with number of meals recorded. if a recorded meal contains fruits and vegetables it is an added advantage.

9. Fish tanks or bowls / Aquarium that consisted of Fish of different species. Number of species grows proportional with badges while the size of each specie is proportional to number of meals recorded. If a recorded meal contains fruits and vegetables it is an added advantage on the size.

FIGURE 6.1: Sample screen-shots of the second prototype

These rules were just arbitrary. The objective was to design challenges with an objective of increasing engagement between intermediaries and beneficiaries when the two users negotiate for interaction with the app.

6.2 Prototype Evaluation Description

The plan in evaluation was to recruit another group of participants. The NGO facilitated access to a group which resided in another side of Philippi where evaluation of the first prototype was conducted. The recruitment was facilitated by the same NGO in Evaluation. But the plan didn't materialize as the NGO advised that we try to look for a different group because the group they were working with expressed concerns regarding safety issues after they heard that they were going to be given phones to use throughout the evaluation period. The NGO was concerned of safety of researchers since rumour had spread throughout the community that someone is going to bring phones to that area. This poses risks to both prospective participants and the researcher. In response to that, this plan was revised and the researcher found another township called Langa, which was a bit smaller and more central township, safer than Philippi.

A research facilitator who is a resident of Langa helped with the recruitment process. This time the recruitment criteria were more stringent compared to the previous evaluation. One of the criteria was to have intermediaries that cohabit or live nearby the beneficiaries. Preference was given to school going children as there were more likely to be interested in gamification. A total of nine adult participants were recruited for the study. The distribution between male and female was three(3) and six(6) respectively. Their average age was 49.3 years old (SD=7.9 years). Each adult participants brought one intermediary participant and formed a pair. The distribution of intermediary participants by gender was 3 males and 6 females. The mean age of these intermediary participants was 14 years old (SD=4.3). Eight adults were relatives/familial related to intermediary participants while the remaining adult was just a tenant of her intermediaries' grandmother. Eight intermediary participants were school-going children.

Prior to commencement of the study, both beneficiary and intermediary participants were given information about the study. Participants were informed that the study's cellphone will be collecting their information related to usage of the app, step walked, and diet and this information will transferred to the researcher's computer at University of Cape Town. All participants who were not minors signed informed consent forms while minors signed assents forms that were also signed by their respective guardians/parents.

Once consent and assent forms were signed, one day was allocated to train intermediary participants on use to use the app. After the training each pair was provided with an one android phone ((Samsung GT-S5300) that contained two native app. The first app was a pedometer which was not displaying any useful information apart from raw steps' data. The pedometer task was to send these steps to a server so that they can be presented and viewed in a better format through a web application. The second app

provided a link to the web application so that users don't have to type a URL every time they needed to access the web app.

In order to encourage participation, each beneficiary participant received ZAR 40 worth of airtime four times in a period of three weeks (ZAR 160 in total). To encourage participation of intermediary participants, each pair was credited 300MB of data to use on the Android phone as it was expected that intermediaries would borrow phones to access other things on the internet that are beyond prescribed uses.

I left the app in the field for three weeks before conducting an evaluation. After three weeks I conducted the evaluation which is described on the next sub-section.

6.3 Prototype Evaluation Methods

The evaluation relied in two approaches which are collecting user logs and interviews. In interviews, all respondents were familiar/comfortable with English, therefore, interviews were conducted in English. A total of three(3) intermediary participants, and five(5) intermediary participants were interviewed. These are the only participants that I could reach to during the time of interviews. These were short interviews which lasted up to 15 minutes for one person. All the names of people used are just pseudonyms to protect identity of participants.

6.4 Findings

The key findings were based on social factors and motivational strategies that influenced usage of the app. Some of the findings from this chapter together with findings from the previous chapter (Chapter 5) have also appeared in a conference paper that I co-authored (Katule et al., 2016).

6.4.1 The Role of a Familial Relationship in the Intervention

As it was observed in the previous chapter (Chapter 5), a parent/child relationship may be important in implementation of such an intervention. In this case, a prior social relationship was also very important. Intermediaries that were working with their parents were eager to support their parents because they cared about them.

Usage of each pair was clustered its respective relationship type as shown on Figure 6.2. There were three three types of relationships:parent-intermediary, relative-intermediary,

and not related , with 4, 3, and 1 number of pairs respectively. Usage on each relationship type was measured through three dimensions: (1) the average number of days per pair; (2) the average number of sessions per pair; and (3) the average number of clicks per pair. More usage was observed on pairs with relationship of type parent-intermediary. In the case of parent-intermediary, or relative-intermediary relationships,
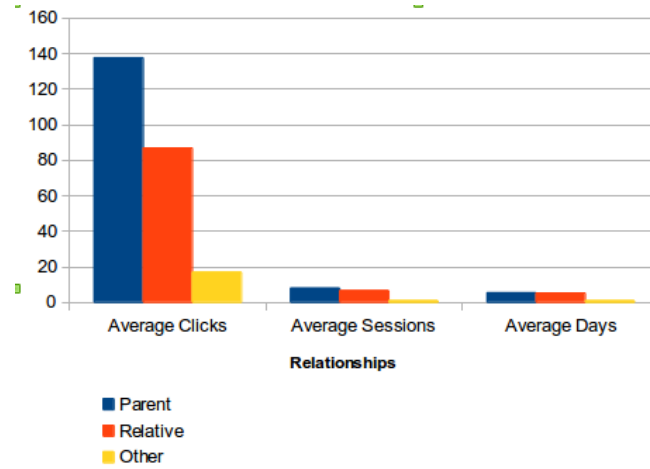
FIGURE 6.2: Usage in three groups of relationships(Katule et al., 2016)

negotiation for interaction that initiated by beneficiary users was more possible because of the nature of the prior relationship. For instance the following two scenarios, requests from beneficiaries where always successful most of the time. For instance, **Zandiwe**, *a beneficiary user, a woman aged 50 years old*, she was working with her sister daughter. Another case was shared by **Lulama**, *an intermediary user, a girl aged 20 years old* who was working with her mother, **Nokanyo**, *aged 57 years old*.

> *"I used to call Lindiwe [an intermediary is aged 16 years of age] like 'Lindiwe there is something that I don't understand'. Or I call her the day before when I walk for a long, I call her to come and help me some way somehow."*
>
> —***Zandiwe***, *a beneficiary*

> *"My mother was the one who was pushing me, let's do it, let's do it. And we spent more time together. But we are always together around that time I do the app at around o'clock at night. So we talk more than before because she would ask 'How am I doing on this?"'*
>
> —***Lulama***, *an intermediary*

There were scenarios of whereby a beneficiary user could request assistance at the time where an intermediary was either resting or occupied by other activities or felt that there

was no urgency in fulfilling such a request. In such a scenario, a social relationship still had to play a role in motivating intermediaries to immediately attend to those requests.

Also for a parent-child relationship, intermediaries demonstrated sense of being co-owners of the information from the system. For instance, Lulama, used the terms "we" or "our" repeatedly to describe actions that needed to be carried out by her beneficiary user as actions that needed to be carried out by both of them.

> *"When I saw the garden I was like yeah, our garden is looking beautiful. Lets do more. Lets take more steps. Lets eat more veges, because it is the veges and fruits that are important."*
>
> —***Lulama****, an intermediary*

In addition, intermediaries from pairs with a prior social relationship had more authority in persuading their beneficiaries to do something in order to win. And it was not solely for winning purposes as they cared for health of the people they were helping. This phenomenon was observed in two pairs with the following excerpts.

> *"I am helping her so it [The app] has to mean a lot to me. I am helping her (Nokhanyo) because she doesn't know anything. She is like 'What is this?'. This is how you do this. She is like 'ooh okay' So it [The app] means a lot to me because I am helping someone I care about."*
>
> —***Lulama****, an intermediary*

> *"Sometimes she used to shout at me. 'No no you didn't eat that thing. Tell me what you ate in the morning. I saw you eating this. It seems there is nothing for fruits, peanuts. You must remind me to check you!"'*
>
> —***Nokhanyo****, a beneficiary user*

> *"It [The app] was really good because my mother was limiting herself on stuff like pies and fat food. I would tell her don't eat this don't eat that. She wasn't eating much vegetables but I was encouraging her to eat vegetables"*
>
> —***Lwazi*** *(an intermediary, a boy aged 14 years old)*

It was observed that for pairs that didn't have a parent-child relationship, interactions between intermediaries and beneficiaries where lesser or absent except for cases where an intermediary was motivated by access to the intervention's phone or motivation affordances provided by gamification. But in cases where intermediaries where driven by those factors, still there was some form of a prior social relationship that played a role,

i.e. relative-intermediary, although it was not as strong as a parent-intermediary relationship. In these cases, of relative-intermediary relationship, even if the intermediary is not motivated by gamification and the phone, they would still provide infrequent help to their beneficiaries. In one case where there was no relationship between an intermediary and beneficiary, even the infrequent help was not available i.e. in the case **Anele** (a beneficiary user, a 47 year old woman, who was working with the granddaughter of her landlord, hence, they were not related. Anele mentioned that every time she passed her request to be helped, her intermediary claimed to be busy and kept on procrastinating by saying they will do it the next day and when that day comes it was the same thing.

Therefore, a familial relationship played an important role in mediating motivation of some intermediaries to help.

6.4.2 Sources of Motivation for the two Sets of Users

In cases were both users of a pair were motivated to use the app and there was a prior social relationship between them, then a pair tended to interact in a more playful manner which brought the two users closer compared to before using the app. This happened in when an intermediary was reporting back the information to a beneficiary user. This made the interaction between an intermediary and beneficiary to be more enjoyable and less tense. These narration from participants describe how the interaction between an intermediary and beneficiary was enjoyable, when the two users were engaging with the app.

> ' When she got time, when she is done with her homework she comes and sees the app. And then laughs at me like 'Yo yo yo [An interjection for Xhosa speakers to express the feeling of amazement by something] you can walk yo yo yo', like 'you walked a lot today' and what what [She was implying to other words said by Lindiwe]"
>
> —**Zandiwe**, a beneficiary

In that excerpt above, Lindiwe showed excitement upon seeing steps walked by Zandiwe. Also Nokanyo mentioned how they laugh when she interacts with her daughter when they are exchanging information retrieved from the app. This playful environment fostered relatedness and made it easier for the two users from a pair to continue engaging with the app.

However in engaging with the app, intermediaries and beneficiaries had different motivational goals. Intermediaries were interested in pursuing a steps or diet goal in order to achieve rewards in gamification. While for beneficiaries, their primary goal was to

achieve more steps for the purpose of informal comparisons with others or for instrumental value to their health. These different sources of motivations are further expanded below.

6.4.2.1 Sources of Motivation in Beneficiaries

One of the factors that played a role in motivating beneficiaries was informal comparison of steps/diet. In the app there was no feature that supported direct comparison of steps or diet. Instead, beneficiary participants who knew each other they implicitly formed a social support group. In this support group, they interacted with each other through either face to face meetings or an SMS/a phone call. These interactions were centred around comparison of steps or diet among each other.

> *"We [with Nokanyo] were talking about what we ate. Like Tuesday I phone Nokanyo to ask her 'Did you eat a lot'. She said 'not today' But she said she ate a lot the day before. It was Monday."*
>
> —***Zandiwe****, a beneficiary*

These kinds of social comparisons led to competitions between beneficiary participants. Competition was a consequence of how the app was existing social context and not an intended goal of design as they happened beyond the app context. Some beneficiary set their target or goals in order to beat others within a social support group. These beneficiary participants were always curious about how other were doing within their support group.

> *"She [Nokhanyo] would ask 'I wonder how so and so is doing'. She would ask them when she sees them. She wouldn't ask on the app "*
>
> —***Lulama****, an intermediary user*

> *" I think I was in competition with steps [She is chuckling]. Because others would have said ooh I have walked, maybe we look at the thing to say let's 1900 steps. And for me I will say no, tomorrow I need to walk more than her because she walked 1900 steps. Then I need to walk 2500 steps"*
>
> —***Ndileka*** *(beneficiary user), 35 years old woman*

Also some beneficiaries got interested to some of the gamification features after *proximate translation by beneficiary users*. Therefore, intermediaries needed interpretation of what

is going on in gamification in order for them to understand it.

> *"She [Nokhanyo] saw the garden. The first day she saw just the house and brownish. She is like 'What is this'. I told her. She said 'Aha! [Expressing dissatisfaction]. It must look green and healthy'. And then she saw the garden again and said 'It is looking good."'*

> —**Lulama**, *an intermediary*

> *"She [His mother] doesn't understand the app. I just tell her that people are having ones twos threes (on the scoreboard and badges) and she laughs"*

> —**Lwazi**, *an intermediary*

Therefore, the most motivating factors for beneficiaries were steps feedback and comparison of steps with others.

6.4.2.2 Sources of Motivation in Intermediaries

There are several factors that motivated intermediaries to use the app, apart a prior social rapport. Factors that manifested in participants' responses include gamification features, effect of intervention's phones, and self-monitoring of steps. Some intermediaries nudged their beneficiary users to do more in steps or to eat healthy, so that their pairs would win rewards offered by gamified elements of the web app. The extent of nudging was evident in pairs with parent-intermediary relationship. Gamification features such as badges and scoreboard mediated competition between intermediaries.

> *"The app challenged me to compete [with others] because there was this lady I think it was Lulama. She was getting points and I was really stressed out because she was reaching the amount I was getting so I was pushing hard to get there. But now I am second. If I was using the app so much I was going to be number one but I am not using the app so much because my mother is not putting her sim card on the phone….It the same like a battle, you are battling with other people. So you must be on your toes with the app and see what is going on with your family"*

> —**Lwazi**, *an intermediary*

Intermediaries were able to interpret some of the intentional persuasive strategies for instance the concept of using the size of the fish in relation to recording of diet. For instance Lwazi was asked what was the size of fish in his tank and his response was as follows, *"They were medium sized because I wasn't really feeding them."*. By not feeding them he implied that he wasn't not doing enough in recording of meals eaten by his

mother. This an example of a connection that was made between playful interfaces and actual health self-monitoring behaviours. But there were also other unintentional persuasive effects resulted from SMS reminders. In one context, three participants (one intermediary and two beneficiaries) were convinced that messages were sent by the researcher. These messages were tailored with participants names and they were auto generated. Therefore, these participants perceived them as the researcher was following their performance and was trying to encourage them. For instance, Nokhanyo, every time she received a message she would call her daughter to come and see and tell that it is coming from so and so (mentioning the name of the researcher). This caused Lulama to panic thinking that there is something she did wrong whenever she heard her mother call her about a received SMS. In a different scenario, Lwazi thought that messages were sent by other participants through a message board that was on the app. Therefore, he passed these reminders to his mother telling her that people are saying to us about eating healthy and the mother was always responding with a laughter. But Lwazi used the same messages to encourage his mother to walk more steps and eat healthy.

Apart from gamification features, a phone had an effect in motivating intermediaries to participate especially the ones that had a prior social relationship with their beneficiaries. Intermediaries were involved in tasks that were non-prescribed in the course of carrying out tasks that within prescribed use. For instance two intermediaries aged 10 and 14 had installed games in intervention's phones that were possessed by their parents. The following is a case of an intermediary who lived a distance from a beneficiary but she came all the way to use the phone and to also interact with gamification.

> *"Lindiwe likes the phone too much. She is always here after school. She lives with my sister on the other side and she comes here everyday. Sometimes I call her to come. We are closer than before. We always talk about the app while other people (relatives) are around. These people also got interested"*

> —***Zandiwe****, a beneficiary*

> *""*

> —***Dlamini****, a beneficiary, man aged 72 years old*

There was also the novelty effect from the self-monitoring tasks (diet's pie chart and steps' bar chart). Some intermediaries got excited to see visualization of information about people they cared about. For instance one intermediary aged 10 years old mentioned that steps were the most interesting out of all features.

6.4.3 Perceived Value in Using the Prototype

Beneficiaries mentioned that they had gained value inform of knowledge and their health.

> *"There are a lot of things I didn't know I now know, like how to eat. I know walking is very important. Because you know I am fat. When I stay on the bed the whole day my blood doesn't circulate."*

—***Zandiwe***, *a beneficiary*

> *"The app helped me because sometimes you don't realize you eat more carbohydrate than fruits. You just eat bread but you don't know that bread is carbohydrate. So when it says large amount of carbohydrate, so you know I am eating large amount of carbohydrate. You think now I must eat more fruits than meat or less meat. So for me automatically it helped me to think that I need to eat large amount of fruits."*

—***Ndileka***, *a beneficiary*

The case of Ndileka above is referred to as cognitive dissonance. This is why self-monitoring is so important because it shows an individual if there is a discrepancy between their beliefs and their actions. Cognitive dissonance supports individuals to restore consistence between beliefs and actions(Oinas-Kukkonen and Harjumaa, 2009)

Intermediaries who engaged with the app also reported that their beneficiaries had have become more knowledgeable about living healthy.

6.5 Discussion

Existing social rapport is important for this kind of intervention. Social rapport creates a conducive atmosphere for using different strategies to motivate both intermediaries and beneficiaries. Social rapport and external motivation sources go in parallel and may depend on each other. For instance, external sources motivation such as phone effect and gamification can enhance an existing familial relationship as it is suggested on the findings. Perceived relatedness between family member had increased. In addition, familial relationship created an opportunity of utilizing young family members as persuaders for behaviour change. These intermediaries can create intents to persuade. This approach relied on social rapport within a household which can be much stronger than a social rapport with an individual who is not a family member. This approach is different from existing approaches in ICTD context. For instance there is a project in India that leveraged trust between community health workers and expectant mothers

for persuasion (Ramachandran et al., 2010a,b), and this trust was built based on persuasive information that community health workers (CHWs) possessed on their phones. Therefore, the prior social rapport is relatively weak, and the influence of these CHWs can be limited to infrequent visits, and much of the persuasive strategy relies on the messages possessed by CHWs (Katule et al., 2016).

Apart from the prerequisite of a prior social relationship, motivation strategies are important as they strengthen on what already the social relationship that exists. Intermediaries and beneficiaries had different motivational needs when engaging with the app. Intermediaries focused on gamification part as their primary objective. Steps and meals were secondary objectives since they were some how linked to the gamification part. Beneficiaries considered steps and meals as their primary objective. Intermediaries competed in points on the leader board but beneficiaries competed on the number of steps walked or healthy meals. Therefore, in this context there are two sets of users that need to be persuaded differently since they have different objectives. Motivational strategies for the two users need to be examined separately, and a designer has to come up with an optimal strategy that will combine motivational strategies for the two groups. An understanding of context is crucial and this has been emphasized by (Oinas-Kukkonen, 2013; Oinas-Kukkonen and Harjumaa, 2009).

If we delve into the sources of motivation by intermediary users, one can see motivation is of twofold. The first dimension has an aspect ego-involved and the second dimension has an aspect of task mastery climate. The ego involved aspect is exhibited through review of statements by the following two intermediary users (**Lwazi** and **Lulama**). Let's refer to one excerpt by **Lwazi** which mentioned about being stressed out upon seeing others coming to the top of the leaderboard. If one interprets that statement through the view of internalization of behaviour regulation discussed on the literature review chapter, the above scenario promotes introjected regulation of where there is ego involved; hence usage in such context may appear to be influenced by attempts to outperform others. Also the same emphasis on outperforming others is exhibited by **Lulama**. So the aforementioned comparisons were respect to the leaderboard. The aspect of motivation that focuses on problem solving or task mastery is demonstrated on the excerpt by **Lulama** of where she was explaining the discussion with her mother (**Nukhanyo**) about the meaning of the garden. From this conversation, **Nukhanyo** emphasizes that their garden must look green. Also in some of **Lulama**'s conversations, she kept on emphasizing by making their garden green by eating more vegetables. Therefore, both **Lulama** and **Nukhanyo** are able to make a connection of what they need to do in order master the task of making the garden greener.

The two aspects of motivation of which one promotes ego-involved climate, and the other promotes task-mastery climate are expanded on, findings of the next chapter (Chapter 8), the overall discussion chapter (Chapter 7) which attempts to collate the findings from all three evaluations in order to broaden the discussion about the implication of this specific finding to the design of gamification.

Chapter 7

Summative Evaluation

7.1 Recruitment of Participants

With help of a research assistant who was a resident of Langa, we managed to recruit a total of fourteen adult participants (beneficiary users) through convenient sampling. Approaching of potential participants for recruitment was done in October 2015. We recruited these participants from two townships in Cape Town: Langa, and Athlone. In Langa there were five adult participants while in Athlone there were nine adult participants. The average age of these adult participants was 44.21 years with a standard deviation (S.D) of 9.99 years. The youngest adult was 26 years of age while the oldest was 60 years of age. Thirteen participants were females. The reason for this gender imbalance is that women were more eagerly to participate compared to men during recruitment. We have already seen this trend even in the study reported in Chapter 6.

Majority of the adult participants had a maximum education level of either grade 7 of primary school or grade 12 of secondary school. Each adult participant (beneficiary user) elected one of their children/grand children to become their respective intermediary user; hence forming a pair of users. Therefore, there were a total of 14 pairs of users. The two members of a pair were required to work together in using the "Family Wellness App" to self-monitor diet and physical activity of an adult member of a pair (a beneficiary participant). As the result of pairing, thirteen beneficiary participants were working with their children, while the remaining one was working with her grand child. The average age of children participants (intermediary users) was 15.42 (S.D=2.06) years. The youngest intermediary user was 12 years of age while the oldest was 20 years of age. The number of females and males intermediary users were equal. Both intermediary users were school going children at primary and secondary school levels.

I gave out detailed information of what the study was all about to both intermediary and beneficiary participants. I informed them about their different modes of which I will collect data such as logs, questionnaires, and interviews. All the beneficiary participants signed informed consent forms agreeing to be part of the study. Since all intermediaries were under 21 years of age (legal age for giving consent in South Africa is 21 and above), they signed assent forms which were also signed by their respective parents/guardians who were part of the study.

One day was allocated for training intermediary participants on how to use the "Family Wellness App". In addition, each intermediary user was given a user manual. After the training, I gave out one Android phone (Samsung GT-S5300) to each pair of participants. These phones were installed with two natives apps. The first app was a pedometer and the second one was the main "Family Wellness App". The "Family Wellness App" loaded all its content from a web application hosted remotely at University of Cape Town servers. Each beneficiary participants was required to carry the experiment phone with them all the time in order for the pedometer app to count their footsteps. The two apps (main app and pedometer) were made available to the pairs of participants for a total period of six weeks. Each pair of participants provided the service provider's number of the SIM card that was inserted on their given Android phone. I allocated 1.3 GB of data to each SIM card. In addition each beneficiary participant was given a total of ZAR 240 for the duration of the study. The amount covered for compensation for participants' transportation and time for points where there data collection activities such as administering of questionnaires and interviews. The details of the experiments are outlined on the next section.

7.2 Experiments

This phase of the study evaluated the effectiveness of gamification/rewards in motivating intermediaries to collaborate with their respective beneficiaries in order to utilize the "Family Wellness App". I was comparing two versions of the applications. The first version of the application was simply a logbook or journal that allows each pair of users (1) to record and view diet/nutritional data of the beneficiary member of the pair, and (2) to view progress in accumulation of footsteps of a beneficiary member of the pair. The second version of the application was an extension of logbook meaning that it included all the feature in logbook with an addition of a rewards/gamified subsystem. The experiments took place from the mid-October 2015 to the end of November 2015. The details of how experiments were designed and how data were collected are presented on the next sub-section.

7.2.1 Experiment Design

The study used "within-group" design for the experiments. In within-group design, the same group of participants were exposed to different experimental conditions. This helps to minimize the number of groups needed to test hypotheses as only one group is used for both control and intervention. Another advantage of within-group design is that it minimizes the effect of confounding factors. The only problem with this approach is the learning effect and in addition, it lengthens duration of a study. In order to minimize the impact of the learning effect on the outcome, I randomly assigned pairs of participants to two separate groups referred to as experimental sequences. The first experimental sequence started with the *logbook app* and finished with the *gamified* app. The second experimental sequence started with the *gamified app* and finished with the "logbook app". I used the following abbreviations "LG" and "GL" to refer to respective first and second experimental sequences.

A total of seven pairs of participants were assigned to the LG group while the remaining seven pairs were assigned to the GL group. Both groups spent the first four weeks in their respective first experimental conditions of which were logbook app for the LG group and gamified app for the GL group. After 27 days (four weeks) each group was switched to a different experimental condition; hence after the switching, the LG group started using the gamified app while the GL group started using the logbook app. The second phase of the experiment lasted for a total of 14 days (two weeks).

The explanation of why four weeks in phase 1 and two weeks in phase 2 is as follows. Initially the plan was to have time spent on each experimental condition, be in three(3) weeks intervals, but phase 1 had extended beyond it allocated block of three weeks up to the fourth week as pairs of participants were not available for midpoint assessments at the end of the third week. Therefore, the midpoint assessment was carried out at the end of the fourth week. After the aforementioned assessment, pairs that were in gamified app were switched to logbook app, and those that were in logbook app were switched to gamified app. It was not feasible to extend phase 2 to go up to four weeks as phase 1 due complexity that was going to be introduced as the result of rescheduling duration of experiments from six to eight weeks. Rescheduling was impossible because it was approaching December of where most people travel for holidays, therefore, gathering participants during that time may have been impractical. As the result this shortened the duration of phase 2 to two weeks.

7.2.2 Data Collection Methods and Analysis

Data collection was a triangulation of application's logs,questionnaires and interviews.

7.2.2.1 Family Wellness App Logs

Application's logs consisted of information regarding the time when there were users' activities on the app, the pair that was accessing the app at that time, and the functionality that was being accessed by that pair. Logs were categorized to their respective experimental conditions. Usage was characterized by two dimensions: (1) the number of sessions of where the app had user activity from a particular pair of users, and (2) the number of times certain features were accessed by a particular pair of users. A new session was defined as a period of detection of user's activity in an absence of any activity from this user/pair in the past one hour or more. The number of times in which a certain feature was accessed was defined as the period of detection of user's/pair's usage activity on a certain feature in an absence of any of their usage activity on that particular feature in the past one minute or more, therefore, if clicks are within an interval one minute on the same feature, it means the user is still on the same feature they had opened last time and they have not moved away from that feature since then. If the time difference between clicks is beyond one minute, then it was assumed that the user had gone away or move to a different feature and they are coming to this feature for another iteration of clicks on the feature as the previous iteration of clicks within the that feature they are visiting had finished. The aim of this dimension was to understand where users of the app were likely to go among options of gamification features which were score board (leader board), score badge, botanical garden, and fish tank (fish aquarium).

I carried out comparison of number of sessions between gamified app and logbook in two sub-dimensions. The first comparison entailed comparing the daily total number of sessions between the two experimental conditions for 41 days of experiments. This was the comparison between daily total of all sessions of users in logbook app and daily total of all sessions of users in gamified app.

In the second comparison, it was a pairwise comparison of users' sessions in between logbook and gamification conditions. In order to ensure this comparison of usage doesn't get affected by differing lengths of experimental durations between experimental conditions, I opted to use a relative (normalized) number of sessions as a unit of measurement. In this case I used the number of sessions per day since the number of sessions on a particular experimental condition was relative to the number of days on which a particular version of the app was made available to the pair of users. This number differed between experimental conditions within the same experimental sequence (group). For instance the LG group spent nearly four weeks in logbook app and only two weeks in the gamified app while the GL group spent two weeks in logbook app and four weeks in gamified app. This implies if a pair that belongs to an experimental group (sequence), Z spent an X amount of days in an experimental condition Y and had n number of sessions,

then their normalized number of sessions in experimental condition Y will be $\boldsymbol{n}$ sessions divide by $\boldsymbol{X}$ days. In the process of doing this comparison, I made a decision to exclude four pairs from analysis. These were pairs that faced hurdles on utilizing the app as the result of technical glitches and this affected their ability to fully experience and engage with what was being offered by the two versions of the family wellness app. These pairs are listed on Table 7.1. For **Pair A**, the app failed to load every time the intermediary

TABLE 7.1: Pairs with usability/technical problems that hinder their participation

	Pair	Experimental Sequence	Problem
1	Pair A	GL group	App not loading
2	Pair B	GL group	Lack of data bundles.
3	Pair C	LG group.	Pedometer never transmitted data to the server.
4	Pair D	LG group.	Pedometer stopped transmitting data to the server.

user tried to use it. An intermediary user from this pair complained that the app was unstable. After I made a follow up, I observed that in the house where that pair lived lived in there was a poor Internet signal, hence the app was always failing to load most of the time and this frustrated the intermediary. The second pair (**Pair B**), data was allocated to the wrong phone number at the beginning of experiments but they never reported on time. These two pairs (Pair A and Pair B) had the lowest usage days which were 2 and 3 days respectively and they they had used the app only in gamification condition.

For the last two pairs (**Pairs C** and **D**) on Table 7.1, their pedometers had malfunctioned; hence in Pair C, footsteps' data were never transmitted to the server while in Pair D the pedometer stopped transmitting data on the fourth week of experiments (before switching of experimental conditions). Both of these two pairs were in LG group meaning that they had started with logbook in phase 1 of experiments. Despite the technical glitches these pairs reported higher utilization of the app while in logbook condition compared to other pairs in logbook condition. In this context, intermediary users of the pairs were the main driver of utilization hence their engagement was crucial for sustainable utilization. It was expected that their usage will be even be higher once they were switched to gamification condition as it was for the case of other pairs that were switched from logbook to gamification as shown on Figure 7.1. However, that was not the case as there was no incentive for them to sustain utilization of the app since the failure of the pedometer was coupled with the learning effect; therefore, it lowered their user experience and affected their utilization after being switched to gamification. Steps data were important in gamification condition for pairs of users to advance in

badges and leaderboard points, and for improvement of both the fish tank and botanical garden.
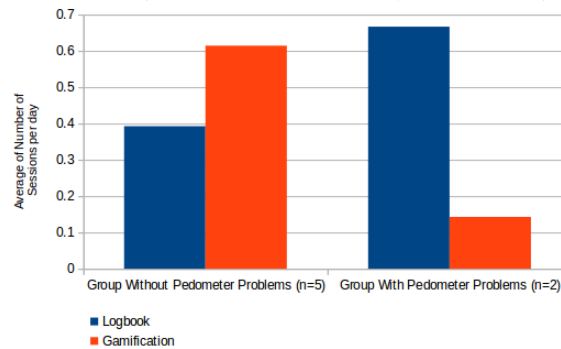

FIGURE 7.1: Average of number of sessions per day for pairs in LG group with and without pedometer problems.

Friendship between the two intermediary users from Pair C and Pair D explained why there were so much similarities in their usage pattern while in logbook condition. Although the pedometer never transmitted data in Pair C since the beginning of experiments, an intermediary user from this pair continued to use the family wellness app because of the informal comparison with an intermediary user from Pair D while they were both still in logbook condition. Their usage in Pair C and Pair D were both 11 days. Their drop out started during gamification condition. Pair C and Pair D used the app for three days and one day respectively. And that usage happened within the first week of starting to use gamification. Since gamification depended on transmission of steps to the server, pedometer problems affected Pair C and Pair D motivations to participate in gamification phase despite their efforts during logbook condition. The learning effect coupled with problems with their pedometers mediated their decrease in usage with the app. An intermediary user from another pair (let's called it Pair G) who was also part of the "LG" group happened to live nearby, was often interacting with intermediary users of Pair D and Pair C. This intermediary user from Pair G shared her concerns about the credibility of rewards offered by the gamified app. This was during the endline interviews. This particular intermediary user didn't appreciate her advancement in badges because she admitted that her peers (the two intermediary users from Pair C and Pair D) did more efforts than her but they were not getting anything so she didn't understand why she was ahead of them. She was referring to their usage during logbook condition as they were both using the "logbook App" at the same time. This proves that usability problems played a role to the some extent in demotivating participation in gamification condition of intermediary users from Pair C and Pair D. So to compare usage the hypothesis of interest is:

1. Hypothesis 1

   - H$_0$:There is no difference in number of sessions between a logbook app and gamified app
   - H$_A$:There is a difference in number of sessions between a logbook app and gamified app

The last analysis on usage logs examined the impact of gamification features on internalization. Perceived usefulness is a predictor of internalization. I devised a term called impressions which is the number of times in which a certain feature had been viewed. So if multiple views by one user/pair on one feature happened within an interval of less than one minute between consecutive views, such multiple consecutive views were treated as one impression. If views on same the same feature differed by a minute or more then each view was treated as one impression. Therefore, the total number of impressions on each of gamification feature was calculated for the number of days in which pairs were assigned to gamification condition. In this analysis we considered all fourteen pairs including the four that had technical glitches. Since this comparison only involved one experimental condition; hence all features had equal chances of being accessed provided that the user has managed to get into the app. Also some feedbacks were delivered through SMS meaning that all pairs had received such interactions regardless of whether the App was accessible or not; therefore, it is under the assumption that pairs pairs that had received SMS feedback could be in position of judging the perceived usefulness of the app. In addition to that, intermediary users were frequently interacting to each other in face to face manner to talk about things in the app. Another assumption is that regardless of the app presence intermediary users would perceive helping their parents on app usage as something that as something that is meaningful. Hence if the user/pair had never viewed a particular gamification feature, they would still get zero as the number of impressions in that feature. The objective was to understand how gamification features affect internalization. On literature review section (Chapter 2), four types of internalization of behaviour regulation were highlighted. Therefore, this analysis also view internalization with respect to the four types of behaviour regulation. The questionnaires that were used to capture aspects of internalization (perceived useful) are mentioned on the next sub-section together with other sub-scales of intrinsic motivation.

7.2.2.2 Questionnaires

The research team administered questionnaires at baseline, mid-line (during switching of experimental conditions), and end-line. These questionnaires targeted both intermediary

and beneficiary participants. The list of questionnaires is provided below.

1. **Intermediaries** Intermediaries had three questionnaires that were administered at baseline, midline, and endline.

   - **Baseline Questionnaire**: Intermediaries participants' baseline questionnaire had three sections. The first section captured demographic information such as age,gender, and number services/apps used on cellphones.The second section included an IMI (Intrinsic Motivation Inventory) questionnaire to assess participants' intrinsic motivation in using cellphones. The third section included an IMI questionnaire to assess participants' intrinsic motivation in helping their parents with cellphone based tasks.

   - **Midline Questionnaire**: Intermediaries participants' midline questionnaire had only one section which included an IMI questionnaire to assess participants' intrinsic motivation in using the family wellness app.

   - **Endline Questionnaire**: Intermediaries participants' endline questionnaire had only one section which included an IMI questionnaire to assess participants' intrinsic motivation in using the family wellness app.

2. **Beneficiaries**

   - **Baseline Questionnaire**: Beneficiary participants' baseline questionnaire had four sections. The first section included an IMI questionnaire to assess participants' intrinsic motivation in using the family wellness app. The third section included an IMI questionnaire to assess participants' intrinsic motivation in self-monitoring of diet/nutrition. The fourth section included an IMI questionnaire to assess participants' intrinsic motivation in self-monitoring of physical activity.

   - **Midline Questionnaire**:Beneficiary participants' midline questionnaire had three sections. The first section included an IMI questionnaire to assess participants' intrinsic motivation in using the family wellness app. The third section included an IMI questionnaire to assess participants' intrinsic motivation in self-monitoring of diet/nutrition.The fourth section included an IMI questionnaire to assess participants' intrinsic motivation in self-monitoring of physical activity.

   - **Endline Questionnaire**: Beneficiary participants' endline questionnaire had three sections. The first section included an IMI questionnaire to assess participants' intrinsic motivation in using the family wellness app. The third

section included an IMI questionnaire to assess participants' intrinsic motivation in self-monitoring of diet/nutrition.The fourth section included an IMI questionnaire to assess participants' intrinsic motivation in self-monitoring of physical activity.

I developed the IMI questionnaires with the guidance of materials found on a "Self-Determination Theory"[1] website which is maintained by researchers working on the theory including Richard Ryan and Edward Deci(Deci and Ryan, 1985b) whom were early pioneers in developing the theory. I pretested these questionnaires during the informative evaluation of prototype II in chapter 6. The most important sub-scales for our theoretical construct were perceived competence and perceived autonomy which are part of the three basic psychological needs. The relatedness sub-scale is not yet validated but it was included in all questionnaires. Other sub-scales that were included all questionnaires or some of the questionnaires were perceived enjoyment, and perceived useful. Perceived enjoyment is the only direct measure of intrinsic motivation while perceived competence and perceived autonomy are predictors of intrinsic motivation. Self-Determination theory suggests that a behaviour can be started as externally motivated and if external motivators support the three basic psychological needs which are relatedness, competitiveness, and autonomy then a behaviour that was once externally motivated can be internalized and users will start doing it because it is a good thing to do. Perceived useful is a predictor of internalization.

In addition to the aforementioned sub-scales, perceived efforts also appears in specific questionnaires (i.e self-monitoring of diet and activity, use of cellphone). This additional sub-scale was included as part of the package of IMI questionnaire inventory as it may be directly linked to the important sub-scales. However, its results were of less interest to the theoretical constructs of this research.

The overall IMI scores were computed by averaging the scores from each sub-scales. In each question from the IMI sub scales, respondents were supposed to rate there experience in a scale of 1 to 7 points which means that 1 implies the statement is "not true at all" and 7 means the statement is "very true".

There were two main objectives of using the IMI questionnaire. The first objective was to assess the ability of the two prototypes in supporting the participants with the three basic psychological needs. The difference in experimental durations was expected not to have any effect on motivations to use either of the two systems since both logbook and gamification were both present in both phases of experiments. Therefore, effects on

---

[1]http://www.selfdeterminationtheory.org/intrinsic-motivation-inventory/

motivations due to different durations were expected to cancel each other during analysis. I compared between the capability of the two prototypes in affording three basic psychological needs suggested by self-determination theory. In addition, I also included perceptions on enjoyment as it is a direct measure of intrinsic motivation. The corresponding scales from the IMI questionnaire were administered at midline and endline . Therefore, there were four main sub-scales; perceived competence, perceived autonomy, perceived enjoyment and perceived relatedness. There were also one additional supporting sub scale which was perceived useful of which its purpose was to extract pattern on internalization as far as gamification features are concerned.

The second objective of using IMI questionnaires was to assess motivations/self-determinations of beneficiaries in self-monitoring of diet and activity, and motivation/self-determination to use cellphone of both intermediaries and beneficiaries. These IMI questionnaires included perceptions of beneficiaries on enjoyment, competence, autonomy, relatedness, enjoyment, effort, and usefulness.

The hypotheses of interest to both intermediaries and beneficiaries on intrinsic motivation's sub-scales related to usage of the app in different experimental conditions were:

2. Hypothesis 2

   - H_0:There is no difference in perceived competence in using the app between a logbook app and gamified app
   - H_A:There is a difference in perceived competence in using the app between a logbook app and gamified app.

3. Hypothesis 3

   - H_0:There is no difference in perceived autonomy in using the app between a logbook app and gamified app
   - H_A:There is a difference in perceived autonomy in using the app between a logbook app and gamified app

4. Hypothesis 4

   - H_0:There is no difference in perceived relatedness in using the app between a logbook app and gamified app
   - H_A:There is a difference in perceived relatedness in using the app between a logbook app and gamified app

Each of the four aforementioned hypotheses was tested twice. The first test was to intermediary users' scores and the second on beneficiary users' scores. There were also hypotheses of interest for beneficiaries in self-monitoring of behaviours reported below:

5. Hypothesis 5

- H_0:There is no difference in the overall self-determination to self-monitor diet of between a logbook app and gamified app

- H_A:There is a difference in the overall self-determination to self-monitor diet of between a logbook app and gamified app

6. Hypothesis 6

- H_0:There is no difference in the overall self-determination to self-monitor activity of between a logbook app and gamified app

- H_A:There is a difference in the overall self-determination to self-monitor activity of between a logbook app and gamified app

In motivations to self-monitor diet and activity, I excluded pairs (A,B, C, and D) from Table 7.1 with problems that led to discontinuation of usage. In total only ten out of fourteen beneficiaries had their results included for analysis in order to have only beneficiaries who had meaningful engagement with the app through their respective intermediaries. In the comparison for self-monitoring of diet and activity, the first IMI comparison entailed comparing the IMI score of each participant at baseline, midline, and endline regardless of an experimental condition. In the second comparison I compared scores at baseline, and at both logbook and gamification conditions. The IMI score was computed from the average of all scores from sub-scales of perceived competence, perceived autonomy, perceived relatedness, perceived enjoyment, perceived effort, and perceived usefulness. I used one way ANOVA with repeated measures to test if there was a difference between scores at: (1) baseline, midline, and endline, and (2)baseline, logbook and gamification. I used Mauchy's test[2] to checked if different measuring points had the same covariance in each ANOVA test I carried out and this helped in deciding of whether to "Sphericity Assumed","Greenhouse-Geisser", or "Huynh-Feldt" of SPSS output.

Before each statistical test, samples were tested to find if they follow normal distribution *"Shapiro-Wilk Normality Test"*[3]) was used to test for normal distribution. For the case of paired samples, the difference between repeated measures of each data point was used to test for normality. In case there was no normality, I would apply a log transformation on the original data, and repeat the normality test again. If normality is achieved I would proceed into using statistical tests that assume normality such a t test with repeated measures or a one way ANOVA with repeated measures. In all

---

[2]Read more on how Mauchy's test is used from http://www.statisticshell.com/docs/repeatedmeasures.pdf

[3]http://sdittami.altervista.org/shapirotest/ShapiroTest.html

cases of repeated measured, normality was achieved on the original data, as the result only statistical tests that assume a normal distribution were used. For the case of of independent samples, each sample was tested for normality. In the absence of a normal distribution in any of the two independent samples, a log transformation was applied in this context. There was a case of two independent samples where a log transformation couldn't result into any normal distribution, therefore, as the result, it was resorted to the use of a non-parametric test called Mann-Whitney U Test as will be reported on the findings.

7.2.2.3   Interviews

I also conducted short unstructured interviews at midline and endline. I selected fewer intermediaries and beneficiaries for the interviews. Interviews responses were important in supplementing data collected through questionnaires and application's logs. All the names used to refer to either which participant excerpts came from or just a particular participant, are pseudonyms to protect confidentiality of participants.

7.3   Findings

There were four primary outcomes in analysing the findings and these are: (1)usage trend of the app; (2) user experience/intrinsic motivation of both intermediaries and intermediaries in using the app; (3) intrinsic motivation of beneficiaries in self-monitoring of diet/nutrition; and (4) intrinsic motivation of beneficiaries in self-monitoring of physical activity.

7.3.1   Findings on Application's Logs

The average number of days on which pairs used both versions of the application was 10.5 (SD=7.39) days. The most active usage was from a pair that utilized the app for a total of 26 days. The less active usage was from a pair that had used the app for only two days out of 41 days. Figure 7.2 demonstrates trends on total daily usage's sessions in between logbook and gamification conditions. These trends indicate that in most days a gamified system had more total number of sessions compared to logbook. This is supported by a statistical comparison of daily total number sessions accumulated from all users in each experimental condition which showed that gamification condition had a significant total number of daily sessions compared to logbook as demonstrated by Mann-Whitney U Test on Table 7.2.
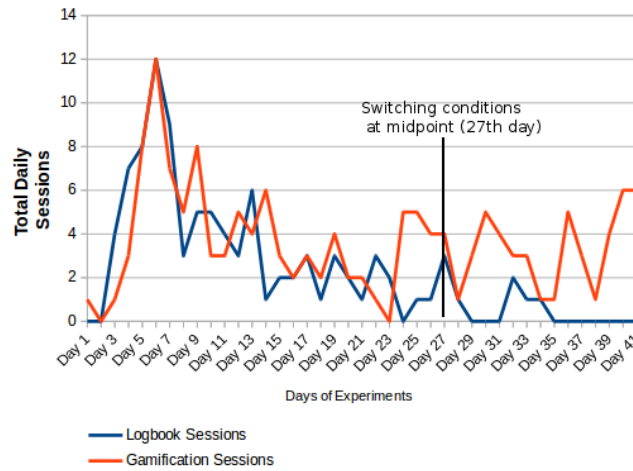
FIGURE 7.2: Total daily number of sessions from the two experimental conditions.

TABLE 7.2: Daily usage comparison between Logbook and Gamified systems for 41 days

Groups	N	Rank Average	Sum Ranks	U	Z	P
Daily logbook sessions	41	33.72	1701.5	1159.5	-2.9538	0.00318
Daily gamification sessions	41	49.28	1701.5			

An interesting phenomenon that expands on the usage pattern of Figure 7.2 above is that one of Figure 7.3 which shows usage trends of LG (logbook-gamification) and GL (gamification-logbook) groups. It can be observed that there is a sudden drop in number of usage sessions for users/pairs in GL group after being switched from gamification app to logbook app. This pattern suggests that most behaviour regulation during gamification condition was as the result of ego-involved (introjected regulation). This hypothesized situation is supported by a further exploration on number impressions on gamification features. On checking the average impressions among the four gamification, leaderboard seems to be having the highest average number of impressions as shown on Figure 7.4. I conducted statistical comparison on the number of impressions between leaderboard and each of other gamification features (score badges, botanical garden, and fish tank). It was found that the number of impressions was statistically significant higher in leaderboard (M=9.93;SD=13.90) compared to score badges (M=4.71; SD=5.50) (t (13) =2.1747; p=0.0487). There was no statistical significance on either number of impressions between leaderboard (M=9.93; SD=13.90) and botanical garden (M=4.79; SD=5.26) (t(13)=1.716; p=0.1096) or number of impressions between leaderboard (M=9.93; SD=13.90) and fish tank (M=5.86; SD=7.40) (t(13)=1.5707;
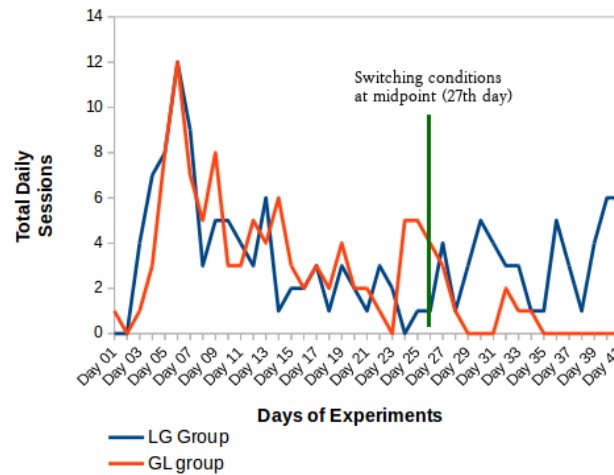
FIGURE 7.3: Total daily number of sessions from the two experimental conditions.
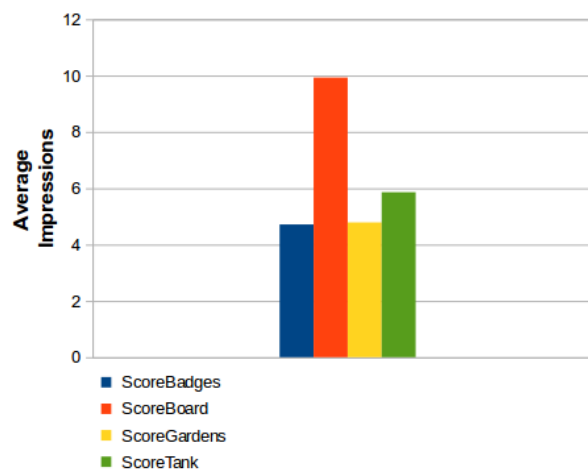
FIGURE 7.4: Total daily impressions for two groups (LG and GL).

p=0.1403).However, the trend shows dominance of leaderboard over other gamification features.

A further exploration on gamification features' impressions revealed some insights on the trend of promotion of, ego involved, and task mastery, climates. This exploration follows the discussion of the previous chapter (Chapter 6) of where it was observed that some statements from qualitative feedback reflected that gamification features tended to promote either task mastery climate or ego-involved climate. In that previous discussion there was an indication that the leaderboard was likely to promote the ego-involved climate on some intermediary users while features like fish tank or botanical garden were likely to promote the task mastery climate. Literature suggests that promotion of task mastery climate may foster integrated internalization of behaviour regulation

while promotion of ego-involved climate may only promote introjected internalization of behaviour regulation (Saksono et al., 2015).

Since perceived usefulness is the only predictor of internalization as reported on the methods section above, therefore, one of the logical steps was to compare perceived usefulness scores between intermediary users who had visited leaderboard more often than other gamification features (number of impressions in leaderboard is greater than the number of impressions on any of the other gamification features) and those intermediary users whose number of impressions on leaderboard was almost similar or less to the number of impressions on any of the other gamification features. Since the average number of impressions on botanical garden, score badges, and fish tank were not so distant from each other as indicated on Figure 7.4, I selected only the botanical garden as a point reference (to represent features that may promote task master climate) for comparison with leaderboard(to represent those features that may promote ego-involved climate). Perceived usefulness was about how intermediaries rate the usefulness of the app to both their parents well-being and to their own perspectives. An assumption is that if the regulation is introjected then the intermediaries would careless about usefulness of the app. Therefore, the next task was to compare perceived usefulness between those intermediary users with high leaderboard impressions relative to the botanical garden and those with low leaderboard impressions relative to the botanical garden. In order to know whether an intermediary user falls under high or low group, the ratio was computed and this ratio was the number of impressions on leaderboard divide by the number of impression on botanical garden. Two group were formed based on the median of ratios from all fourteen intermediary user which was 0.91. Seven intermediary users were assigned into a group with ratio $>=$ **Median** while the remaining seven intermediary users where put under a group with ratio $<$ **Median**. Therefore, the comparison was done on perceived usefulness of the gamified app between intermediary users with impressions' ratio $>=$ **Median** and intermediary users with impressions' ratio $<$ **Median**. The two independent samples followed a normal distribution; hence the results of a student t test are shown on Table 7.3) which indicates that the group with ratio $<$ **Median** scored significantly higher that the group with ratio $>=$ **Median**. The implication of this finding is that those that had never accessed the leaderboard or had accessed it fewer times relative to the botanical garden had a higher tendency of valuing the intervention that utilized the gamified app as useful compared to those that had used the leaderboard relatively higher than the botanical garden.

Since the bias on usage of leaderboard showed the significant decrease of scores on perceived usefulness, the next task was to see if that affected gamification condition in general. Let's examine the trend of intermediaries' perceived usefulness between midpoint and endpoint between for both a group with ratio $>=$ **Median** and ratio $<$ **Median**

TABLE 7.3: Comparison of perceived usefulness between group with ratio $>=$ **Median** and group with ratio $<$ **Median** (ratio = impressions on leaderboard/impressions on botanical garden)

Mean	Group with ratio $>=$ **Median**	Group with ratio $<$ **Median**
Perceived usefulness	M=4.143; SD=0.763	M=5.171 ; SD=0.962
	t(12)= 2.2156 ; p=0.0468 ; 95% CI= -2.040 to -0.017	

. An earlier assumption was that the relationship between parents and children would make children to value the app as meaningful; hence the regulation would be considered as either identified or integrated regulation. But from the findings above, the trend indicated that most users concentrated on the leaderboard and as the result those with higher number of impressions of leaderboard compared to number of impressions on other gamification features such as the botanical garden appeared to have low scores in perceived usefulness. In order to verify the significance of the aforementioned trend, the hypothesis of interest was that gamification affected the perceived usefulness of the app through its leaderboard feature. In order to prove this hypothesis, the logical step was to assess perceived usefulness between midpoint and endpoint for the two aforementioned groups. The perceived usefulness was statistically significant higher at endpoint (M=5.4; SD=1.058) compared to midpoint (M=4.67; SD=1.37) (t(6)= 4.9670 ; p=0.0025) for the group with ratio $<$ **Median** while for the group with ratio $>=$ **Median**, there was no statistical significance difference between endpoint(M=4.34; SD=1.081) and midpoint (M=4.66; SD=0.781) (t(6)= 0.8742; p= 0.4156). An intermediary user with the highest ratio, was the one with the lowest scores on perceived usefulness. There was a negative correlation between ratio of impressions (leaderboard/botanical garden) and perceived usefulness without statistical significance (r=0.52; p=0.06; N=14). What can be concluded so far is that it is very likely the leaderboard played a role in hindering internalization since perceived usefulness is a good predictor of internalization. Also high usage of leaderboard suggests most usage in gamification was accounted as introjected regulation of where there is ego-involved. This finding is inconclusive due limitation of the sample size but can be a basis of forming a much larger study with a bigger sample size in order to test the hypothesis.

A different dimension of usage was the one that compares if there was a significance difference on number sessions between two experimental conditions (repeated measures of the same pairs at logbook and gamification conditions). As highlighted in the section that describes the methods above, the four pairs with technical glitches were excluded in order to bring fairness in the comparison of the two experimental conditions (Table 7.1). The finding from this comparison showed that the mean of logarithmic transformed data of number of sessions per day (relative or normalized number of sessions) was

significantly higher on gamification condition, M=0.459; SD=0.336, when compared to logbook condition, M=0.201 ;SD=0.196 with (t(9)= -2.6593 ; p= 0.0261 ; 95% CI= -0.477 to -0.039). The finding above suggests that there was an indication of a significant increase in frequency of daily usage when pairs of users where in gamification condition. The log mean was used in this case because the differences of data points from logbook and gamification didn't have a normal distribution shape. As the result,a transformation was performed using a natural logarithm equation and after that transformation on the original data, the differences of the new pairwise data (logbook and gamification) had a normal distribution shape.

On the next sub sections, user experiences of both intermediaries and beneficiaries are reported.

7.3.2 Intermediaries' User Experience

In most cases, usage of the app within a pair of users was facilitated by intermediary users in proximate enabling and proximate translation. These types of intermediated interactions have been discussed in the work by Sambasivan et al. (2010). Baseline data indicated that interest of intermediary participants in using cellphones was higher than that beneficiary participants. For instance, in overall IMI scores to use cellphone, intermediaries (M=5.76, S.D= 0.41, N=14) scored significantly higher than beneficiary participants (M=5.06, S.D= 0.71, N=13) with (t(25)= 3.1764, p=0.0039, 95% CI = 0.2472 to 1.1589).

If we refer back to the trend on Figure 7.3, it appears as if both gamification and logbook have patterns that are similar. However, after the second week logbook starts to go down on usage while the trend on gamification appears to be steady for a couple of days. One of the possible explanation of why logbook appears to be having the same effect as gamification is the combination may be one or a combination of the two factors: the phone effect, and the novelty effect. The phenomenon of sharing phones was important in nurturing the relationship between intermediaries and beneficiaries. Parents were lending their experimental phones to their kids to access social media sites and games. Having access to a phone while providing help to beneficiary participants can be viewed as one of the motivating factors to intermediary participants who didn't have smart-phones or data bundles in their smart-phones. Some intermediary participants had installed games, other apps on those phones. To understand how the phone had a strong effect on motivation, the relationship between perceived autonomy to use cellphone at baseline and perceived enjoyment to use the app at midline was explored for the group that started with logbook. An interesting phenomenon was revealed. There was a

significant negative relationship between perceived autonomy to use cellphone at baseline and perceived enjoyment to use the app at midline for the LG group (r=-0.84, p=0.017, N=7). An explanation behind this is that those intermediary users with low autonomy to use cellphone had free access to the intervention phone and this increased their interest to participate in the intervention. For instance one intermediary user (**Siyamthanda**) from the LG group who was the youngest (12 years of age) among all reported the lowest score in perceived autonomy to use cellphone at baseline while reported the highest score in perceived enjoyment to use the app at midpoint (after using logbook condition). Her excerpt below also reveals how she had freedom to use the phone while in logbook condition.

> *"I had freedom [in using the app] because sometimes she left the phone with me and I was able to play games"*
>
> —***Siyamthanda****, a female intermediary from Langa, 12 yrs old*

Therefore, there was an inclination that a phone coupled with the novelty effect had mediated engagement for intermediaries that had started with the logbook condition. These intermediaries were helping in return they have access to cellphone to access functionality or services they like. However this finding is inconclusive due to the sample size. However, it highlights the discussion on the direction of what should be explored in future studies. For the GL group it was difficult to isolate the gamification effect from the phone and novelty affect and studies have shown that gamification has novelty effect, however, the trend shows that gamification accumulated more sessions compared to logbook hence gamification alone increased utilization of the family wellness app.

In additional to the novelty and phone effects, and gamification also another factor that contributed to intermediaries interaction with the family wellness app was requests from their respective beneficiaries. There were times where intermediary users opened the app for interaction only upon receiving requests from beneficiaries. In both absence and presence of gamification, intermediaries had to fulfil requests from beneficiaries. But during logbook condition, intermediaries appeared to be less enthusiastic in handling those requests. Some beneficiaries complained that there were several incidences of where their respective intermediary users were refusing to fulfil these requests and it happened more often during logbook condition. It was observed that in most of these cases, intermediary participants' autonomy was violated as requests came at times where intermediary participants were either studying for exams or doing something else and they felt it was not the right time to fulfil those requests. This made some of the intermediary participants to feel that their parents were nagging them. For instance, **Lunga**, a male intermediary participant from Langa, aged 17 years, felt annoyed when his mother

insisted they should interact with the family wellness app while he was busy using social media through the intervention's phone. This happened during logbook condition. Also a similar situation happened to **Jennifer**, female intermediary participants from Athlone, aged 18 years who also felt irritated by her mother's constant requests during logbook condition. In addition she felt the app was not that exciting as she said "*The app was okay first but it started to get boring. You don't want to go into it any more. I think there will be some excitement now if the game comes in. When do we get the game*". She was curious to know when they will be switched to gamification because she thought the logbook condition was boring.

There are two motivational drivers for all requests that were put forward by beneficiary users. The first source of motivation was the instrumental value derived from using the app. The second reason is gamification. Requests that were mediated by gamification fostered a sense of collaboration between members of a pair while in the scenarios where beneficiaries were not concerned about gamification or during logbook conditions, requests tended to be of authoritative nature.

> "*I would always ask him [Kelvin] where are we. Are we first? And what badge do we have? Where are the others? How far is Simon [intermediary] then? How far is that one? 'No mum we are on top. We are first. We are the champions' [during gamification].*"
>
> —***Ayesha***, *female beneficiary, 35 yrs*

This above excerpt from **Ayesha** demonstrates a sense of collaboration between the two members of a pair (an intermediary user and a beneficiary user). The excerpt below came form a beneficiary user in logbook condition and it indicates a beneficiary is having authority of what should be done.

> "*I always start the conversation. Because I always want to make sure if he records because I can't use it. It was difficult for me to use it. [during logbook]*"
>
> —***Sisipho***, *female beneficiary, 43 yrs*

The "Gamified App" was designed in such a way that a pair will earn rewards based on usage and the average number of steps walked by a beneficiary participant who is a member of the pair. The purpose of rewards was to foster users' intrinsic experiences such as competitiveness and a sense of autonomy which are predictors of intrinsic motivation with the goal of improving collaboration between members of a pair. Rewards depended on four parameters and these were the number of steps walked by a beneficiary user, the number of days the app has been used by an intermediary to either to record meals

or to view feedback on meals, points, steps, gardens, etc. The presence of gamification nurtured team work even though the regulation of self-monitoring through intermediary users was mostly introjected (regulation done for the purpose of becoming better than others) as shown on below excerpts.

> *"When I see other people trying to come above me [on the leader board]. I hand over the phone to my mom so she can walk more steps."*
>
> —**Kelvin**, *a male intermediary from Athlone, 15 yrs old*

> *"I told my mom that me myself I want our team to have the highest points. Yes she said she is going to do that."*
>
> —**Celine**, *a female intermediary from Athlone, 16 yrs old*

Through these collaborations there were goals of which in most cases they were set by intermediary users and informed their respective beneficiary about what they wish for the team (pair). A sense of joint ownership of the process was also common for these intermediary users as indicated by the following excerpts.

> *"Sometimes that person may be first so I tell my mom that we must also be at the first place.[She looks at the leader board and she sees so and so is at first place there she talks to her mother that they should also aim for the first position] "*
>
> —**Sophia**, *a female intermediary from Athlone, 17 yrs old*

> *"When he [Leon] looked through it [The app] and sees their points, he would say 'Mom, we need to do something here, because look at their points and our points'. So it was quite interesting."*
>
> —**Jenner**, *a female beneficiary from Athlone, 45 yrs old*

Comparison on virtual rewards among intermediary users motivated them to check the app more often compared to when they were in logbook condition as highlighted on the aforementioned usage findings (sub section 7.3.1). Intermediaries were competing which others on the leader board and talked about their points face to face interactions whenever they met.

> *"He [Leon (her 15 years old son)] likes this exercise (using the app) because among him and his friends, they would have that competition like 'I got more points than you' and that motivated him to get interested with the app"*
>
> —**Jenner**, *a female beneficiary from Athlone, 45 yrs old*

Aforementioned cases above prove that regulation was mostly introjected as it was mediated by the need to be better than others in terms of points or being at the top of

the leaderboard. Other features were not discussed in details in the interviews as intermediary users or beneficiary users who were interviewed didn't give any insights. The desire to be better mediated cheating the rules in some cases. For instance, there was a scenario of one pair of which not only the beneficiary user was using the pedometer, an intermediary was also taking turns to use the pedometer, therefore they were collaborating in accumulating steps. Both an intermediary user and a beneficiary user had discussions of whether the person whose turn it was had walk enough steps. They did this to accumulate more steps and hence more points than other pairs of users.

> "I ask her how far did you walk? She would say she walked very far. She tells me that I must have the phone to walk more steps. She would say 'I got more more walking than you' [They were collaborating with her mother in accumulating steps]. She sometimes writes the steps on the page and she tells me yesterday I day I had more points than you [points referring to steps]"
>
> —**Celine**, an intermediary

The ambiance of competition with others appeared to also affected pairs that had started with logbook conditions as some intermediary users were pushing their beneficiaries to do more by expecting to get rewards once they are switched to gamification condition.

> "I think we talk more (with **Siyamthanda**) than before the family wellness app. Before the family wellness app, after work it was just "Hi" and then I go to my room but now. But now she would come to my room and say let me see your phone, what did you eat today, and write everything down on the phone. So we are more closer than before because of this. Most of the time she used to say that 'we must win this"'
>
> —**Kefiloe**, a female beneficiary from Langa, 26 years old

Interest of intermediary users or pairs in general varied as some exhibited interests on interacting with others through the app while others where focused on achievements (i.e. dominating others in competitions). Gamification appeared to be the most dominant

factor that influenced usage as we have already seen that the frequency of usage showed a higher value in gamification when compared to logbook.

> "We [with Kelvin] were not talking to others because all we wanted was to win. We didn't want them to know but they could see from the app"
>
> —**Ayesha**

Only two intermediaries had tried to interact with others using social features of the app or comment on rewards from their peers. These are some of the comments that were shared by these participants.

> "Fish are increasing neh.[He commented this on a fish tank owned by Kelvin and his mother]"
>
> —**Simon**, a male intermediary from Athlone, 15 yrs old

> "Wow it shows that you are working hard Clara#2.[She congratulated a female intermediary called Clara for being on the second position on Fish tanks.]"
>
> —**Siyamthanda**, a female

However, not all intermediaries had a positive user experience on utilizing gamification, as perceived enjoyment on some intermediary users was lower in gamification compared to logbook despite the fact that there were more sessions reported in gamification compared to logbook. Since the leaderboard drew most attention, it could have played a role in demotivating users with lower performance. Leader-board can demotivate those users that are at the bottom but it can foster aspects of relatedness for all users (Sailer et al., 2013). One way to exclude the impact of this on motivation was to single out intermediary users that never had any advancement in badges but had accessed to the leaderboard for at least two days or those intermediary users that never accessed any gamification feature due the app failing to load but seemed to be interested in accessing gamification features. I used badges as the point of measuring progress for those that had used the leaderboard for at least two days in a row or non consecutively. In this category there were two intermediary users that reported to have higher utilization of gamification features including the leaderboard and never made any progress in badges. These were among users that belonged to teams/pairs that were at the bottom of the leaderboard and their perceived enjoyment was lower in gamification condition compared to logbook condition. One user was from the 'LG' group (Keller), while the other one was from the 'GL' group (Leon). Their beneficiary participants were not walking enough steps despite the fact that these two intermediaries had put more efforts in using
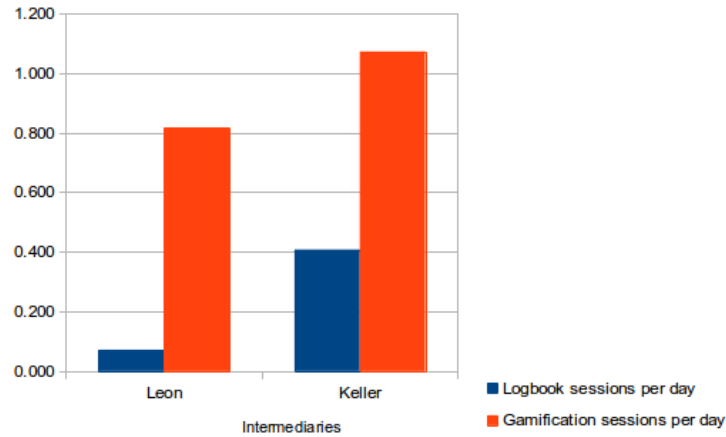
FIGURE 7.5: Logbook Vs Gamification for two users that had no technical problems but never had any badge advancement.

the app during gamification condition than in logbook condition as shown on Figure 7.5.

In the category of users with technical problems, there are two intermediary users of which one had attempted to access the leaderboard and the pedometer was not working, and in the other user the app was failing to load completely hence couldn't access any feature. The two users in the latter category are part of the four users reported to be having usage problems as reported on Table 7.1. The remaining two users from Table 7.1 never accessed a leaderboard although they had accessed other gamification features; hence were not so much exposed to the peer comparison as the result of using the leaderboard although they had visited other gamification features. The perceived enjoyment of these two users who had accessed all gamification features except for the leaderboard was higher in gamification condition compared to logbook condition.

There was also a case of where one user was a bit pessimistic about the credibility of the gamified system because her peers appeared to have more interest with the app, but were at lower positions on the leader board compared to her.

> "It [The experience in using the gamified app] was the same as last time (during logbook condition) except for the game part. I was actually above some of the others. That was weird. Because they were more interested in the app than me."
>
> —**Akhona**, a female intermediary from Langa, 16 yrs old

On the aforementioned excerpt, *Akhona* was referring to the two intermediary users from pairs C , and D that reported to have usage problem on Table 7.1 as these two users used the app more often in logbook condition compared to *Akhona*, therefore,

Akhona's anticipation was that they would be more competent than her once switched to gamification but contrary to her expectations she was ahead of them. Therefore, even in perceived competence, Akhona reported lower score in gamification compared to logbook despite using gamification for 7 out of 14 days and logbook for only 4 out of 27 days. However, she reported more enjoyment in gamification condition than in logbook condition.

Therefore, in comparison between logbook and gamification for the support of the three basic psychological needs, a decision was made to exclude the four pairs whose perceived enjoyment was largely affected by either technical glitches or inability to participate fairly in gamification as the result of the app not being able to tailor challenges with skills of intermediary users as their performance relied to the great extent to the performance of their respective beneficiary users. For the intermediary users in the latter case, an assumption was that a negative experience was the result of failure of the gamification design to match challenges with abilities. i.e. efforts of beneficiary differed differed hence their performance had an effect on the overall performance of their respective team. This implies in that context, intermediary users had little control of the performance of their beneficiaries. Some intermediaries reacted in a negative way when they thought their respective intermediaries were not complying to carry the pedometer all the time.

> "Sometimes may be I forget to take the phone when I go walking and he would ask me 'did you take the phone with you' Ooh Gosh I forgot. Because when I walk to Park Town to exercise and sometimes I am in such a hurry I forget the phone, he will be crossed with me."
>
> —**Jenner**, a female beneficiary from Athlone, 45 yrs old

The aforementioned excerpt demonstrates how an intermediary user was attempting to control his beneficiary user as result competition influenced by peer pressure from intermediary users in other pairs. Therefore instead of gamification being something enjoyable in this context it resulted into a negative reaction that could threaten an existing social rapport between a parent and a child.

As for reasons stated above, four intermediary users in total were excluded in the analysis of self-determination theory. As the result only 10 out of 14 intermediary users were considered in the sub-scales of perceived competence, perceived autonomy, and perceived relatedness.

The findings on Table 7.4 indicate that perceived competence of intermediaries in using the "Family Wellness App" was significantly higher in the gamified condition than in the logbook condition in the ten intermediaries that were analysed. Perceived autonomy and

TABLE 7.4: Comparison of 10 intermediaries' scores on sub-scales of perceived competence (PC), perceived autonomy (PA), and perceived relatedness (PR)

Mean	Logbook	Gamification
Perceived competence	M=5.23; SD=1.02	M=5.96; SD=0.66
	t(9)=3.495; p=0.0068 ; 95% CI= -1.204 to -0.258	
Perceived autonomy	M=3.95; SD=0.86	M=3.96; SD=0.94
	t(9)= -0.027; p= 0.98; 95% CI= -0.596 to 0.582	
Perceived relatedness	M=4.22; SD=0.63	M=4.37; SD=0.9
	t(9)= -0.719; p=0.49; 95% CI= -0.622 to 0.322	

perceived relatedness were all not different between gamification condition and logbook condition.

7.3.3 User Experience of Beneficiaries

As most beneficiaries only interfaced with the app through intermediary users, beneficiaries' user experience relied on cooperation they got from intermediaries. On support for the three basic psychological needs, there was no difference between logbook and gamification. However, aspects of relatedness (N=14) appeared to improve significantly with time when compared between midline (M=4.43; S.D=0.92) and endline (M=5.38; S.D=1.08) with (t(13)= 2.3736; p= 0.0337; 95 % CI=-1.819 to -0.0855). Therefore, the intervention in general made beneficiaries felt more related to others (their respective intermediaries and other beneficiaries) who were part of the intervention.

On utilizing the app through intermediaries, there are cases where beneficiaries had a negative experience as result of intermediaries refusing to assist upon being given requests. This happened in cases of where intermediary users didn't feel like helping because of being occupies by other tasks such as reading for exams or because they felt the app was boring especially in logbook condition. Younger beneficiaries had a tendency of being keen to compete with others. But for older intermediaries, interests what happening in gamification In addition to that, from Figure **??**, a combination of younger intermediary and beneficiary users had more sessions in average and this is because gamification influenced younger intermediary users to use the app, while it also influenced younger beneficiaries to pass their requests to their respective intermediaries more often. For instance in interviewing one pair that consisted of a younger intermediary and beneficiary users, this pair had highest number of sessions in gamification. In the course of using the app they both exhibited playfulness behaviours in engaging with gamification of whereby they discussed strategies about beating other teams. So every time a beneficiary user from this pair would request her intermediary to open the app so that she can see if they are ahead of other teams.

In the next sub-section, the IMIs in self-monitoring of diet and activity are reported. Four pairs with usage problems (Table 7.1) were excluded.

7.3.3.1 IMI in Self-Monitoring of Diet

The results on self-monitoring of diet (baseline, midline, and endline) are shown on Table 7.5. The Mauchly's test indicated that the assumption of sphericity was not violated with $\chi^2(2)=3.76$, p=0.152. The results (N=10) on "Self-monitoring of Diet" shown on Table 7.5 were from "Sphericity Assumed" output. ANOVA showed that there was a significant difference of average IMI scores on self-monitoring of diet measured at baseline, midline and endline. A finding from a pairwise comparisons (a paired student

TABLE 7.5: Comparison of ten beneficiaries' IMI scores in self-monitoring of diet at baseline, midline and endline

Mean IMI Score	Baseline	Midline	Endline
Self-monitoring of Diet	M=4.48; SD=1.24	M=5.07; SD=1.19;	M=5.55; SD=0.95
	F(2,18)=3.787; p=0.042		

t-test) indicated that the IMI score at endline was significantly higher than at baseline (Table 7.6). There was no significant difference on baseline versus midline and midline versus endline (Tables 7.7, and 7.8). Motivation to self-monitor diet appeared to increase with time as shown on Figure 7.6. The interpretation of the above findings are that the wellness app appeared to had a significant effect of time on motivation of beneficiaries to self-monitor their diet.

TABLE 7.6: Pairwise comparisons of IMI scores in self-monitoring of diet: Baseline versus Midline

Mean	Baseline	Midline
IMI Score	M=4.48; SD=1.24	M=5.07; SD=1.19
	t(9)=-1.298; p=0.227 ; 95% CI= -1.621 to 0.439	

TABLE 7.7: Pairwise comparisons of IMI scores in self-monitoring of diet: Baseline versus Endline

Mean	Baseline	Endline
IMI Score	M=4.48; SD=1.24	M=5.55; SD=0.95
	t(9)=-2.457; p=0.036 ; 95% CI= -2.06083 to -0.08517	

The aforementioned ANOVA finding on comparison among baseline, midline, and endline doesn't discern between different experimental conditions of which pairs of users

TABLE 7.8: Pairwise comparisons of IMI scores in self-monitoring of diet: Midline versus Endline

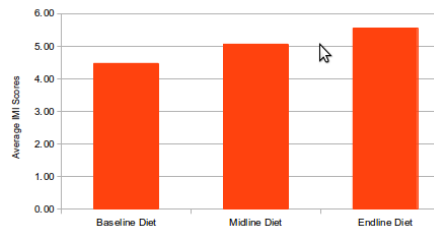| Mean	Midline	Endline
IMI Score	M=5.07; SD=1.19	M=5.55; SD=0.95
	t(9)=-1.975; p=0.08 ; 95% CI= -1.0342 to 0.07017	

FIGURE 7.6: Trend on Average IMI Scores of Self-Monitoring of Diet at Baseline, Midline, and Endline.

were exposed to. The ANOVA finding (N=10)(Table 7.9) on the comparison of IMI scores to self-monitor diet, among baseline, logbook, and gamification conditions showed that there was no significant difference of average IMI scores on self-monitoring of diet measured during baseline, logbook and gamification conditions. This finding is from the "Sphericity Assumed" output of the ANOVA test since the Mauchly's test indicated that the assumption of sphericity was not violated with $\chi^2(2)$=2.19, p=0.335. The trend on averages shows both logbook and gamification to be slightly higher than baseline as shown on Figure 7.7. The conclusion from this finding is that both versions of the prototype have shown an indication of increasing motivation of beneficiaries to self-monitor diet.

TABLE 7.9: Comparison of ten beneficiaries' IMI scores in self-monitoring of diet at baseline, after logbook, and after gamification conditions

Mean IMI Score	Baseline	Logbook	Gamification
Self-monitoring	M=4.48; SD=1.241	M=5.28; SD=1.05	M=5.34; SD=1.16
of Diet	F(2,18)=3.787; p=0.087		

7.3.3.2 IMI in Self-Monitoring of Activity

The results (N=9) on self-monitoring of activity are shown on Table 7.10. The results are based on a sample of nine beneficiary users as one participant didn't complete this part of the questionnaire at baseline. The Mauchly's test indicated that the assumption of sphericity was violated with $\chi^2(2)$=8.248, p=0.016. The value ϵ on Greenhouse Geisser
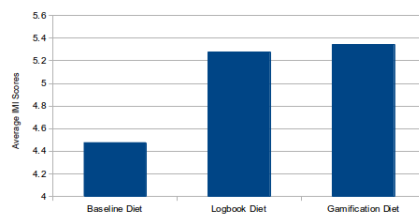
FIGURE 7.7: Trend on Average IMI Scores of Self-Monitoring of Diet at Baseline, Logbook, and Gamification.

was "<0.75", therefore, the results on "Self-monitoring of Diet" shown on Table 7.10 were selected from "Greenhouse-Geisser" output. ANOVA showed that there was no significant difference of average IMI scores on self-monitoring of activity measured at baseline, midline and endline. The trend of means appears to increase from baseline to endline as shown on Figure 7.8.

There are several factors that could have contributed to results not being significant among baseline, midline,endline points,. The first hypothesized reason is tracking of physical activity appeared to be easy in majority of the participants even without tracking devices as people can estimate the distance they walk daily and they consider this as tracking even though they might have means to record this information, hence their motivation was high at baseline unlike diet self-monitoring which they consider it to be cumbersome due to external barriers such as health food being expensive, therefore at baseline participants felt more motivated to track their activity. The second hypothesized reason is that the sample size was small hence there was a smaller power in detecting significant difference. But we have seen that the trend in motivation increases with time.

TABLE 7.10: Comparison of ten beneficiaries' IMI scores in self-monitoring of activity at baseline, midline and endline

Mean IMI Score	Baseline	Midline	Endline
Self-monitoring	M=4.82; SD=1.002	M=5.28; SD=1.003	M=5.41; SD=0.894
of activity	F(1.182, 9.455)=2.936; p=0.116		

The finding from an analysis (N=9) that examined if there is a difference among baseline,logbook, and gamification in self-monitoring of activity, showed that there was no significant difference of average IMI scores on self-monitoring of activity measured at baseline, logbook and gamification (Table table:imiactivity2benf). The Mauchly's test indicated that the assumption of sphericity was violated with $\chi^2(2)=6.788$, p =0.034.
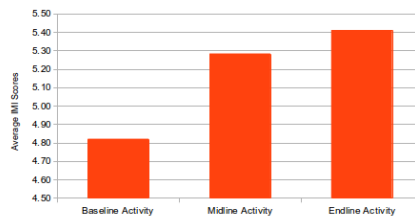
FIGURE 7.8: Trend on Average IMI Scores of Self-Monitoring of Activity at Baseline, Logbook, and Gamification.

The value of ϵ on Greenhouse Geisser was "<0.75", therefore, these results on "Self-monitoring of Activity" were selected from "Greenhouse-Geisser" output of oen way with repeated measures ANOVA test. The trend in motivation increases in both logbook and gamification compared to baseline as shown on Figure 7.9

TABLE 7.11: Comparison of ten beneficiaries' IMI scores in self-monitoring of activity at baseline, logbook and gamification

Mean IMI Score	Baseline	Logbook	Gamification
Self-monitoring	M=4.82; SD=1.002	M=5.33; SD=0.9762	M=5.37; SD=0.9276
of activity	F(1.234, 9.872)=2.783; p=0.123		
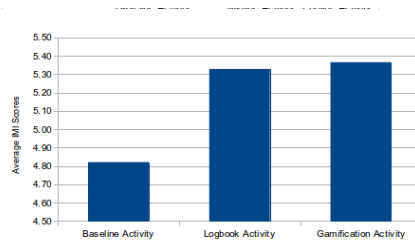
FIGURE 7.9: Trend on Average IMI Scores of Self-Monitoring of Activity at Baseline, Logbook, and Gamification.

7.4 Discussion

7.4.1 Motivational Affordances' Impact on Intermediaries

As reported above intermediary users facilitated interaction with the app. Intermediaries were motivated to engage with the app mostly because of two main reasons and these were: either to follow up on competition with others or to serve requests from their respective beneficiary users. Gamification was the main source of motivation to

intermediaries and it played a pivotal role in mediating usage during gamification condition or even in logbook condition for intermediary users in pairs that had started with logbook condition before being switched to gamification condition. Expectation of gamification condition at a later stage by some users who had started with logbook condition motivated them to sustain engagement while in logbook before being switched to condition. For instance in a case of **Siyamthanda**, an intermediary user who talked of winning while still in logbook condition. Therefore, this affected the separation of experimental conditions as users were aware that they will be switched to gamification at some point and it helped increase usage in logbook condition. On perceived competence, the difference between logbook and gamification was statistically significant meaning intermediary users in gamification felt more competent.Statistical significance in difference was not achieved in cases of autonomy and relatedness due to the learning effect and a smaller sample size. Perceived competence and perceived autonomy are the most important predictors of intrinsic motivation.

From the findings it is also evident that gamification played a role in improving intermediaries' perceived enjoyment (a direct measure of intrinsic motivation) in using the app except for fewer cases of where it appeared to harm perceived enjoyment due to several reasons that have already been highlighted on the findings section above. For instance the use of leaderboard contributed to both positive and negative depending on individual characteristics of an intermediary user and characteristics of a team in general. Intermediary users responded differently to gamification due to a great variation in users' traits (personalities) and skills possessed by their respective team mates (beneficiaries) of where this contributed to having such mixed results. Literature has vastly explored how important it is to tailor game design mechanics to players' personalities. In one survey that investigated how preferences of motivational affordances is linked to individuals' personality traits concluded with some of the following insights: (1) extraverts tend to be motivated by points, levels, and leaderboard; (2) avatars are likely to be preferred by people with high levels imagination; (3) extraverts prefer to be centre of the stage; hence the position they desire in a feature like a leaderboard is the top one; (4) introverts may not be happy to be in a crowd of strangers; (5) and so on.. (Jia et al., 2016). Personalities that are exhibited by game players may also cross to gamification since the boundary between gamification and games is diminishing (Ferro et al., 2013). What may be considered just as a simple gamified system in one context may be socially perceived as a game in a different context (Deterding et al., 2011). Personalization of healthy interventions to gamer types is already commonArteaga (2010); Orji et al. (2013b) but has only been used in the context of direct users of technology and not in the context of intermediary and beneficiary users.

Apart from tailoring of game mechanics another aspect of personalization is on involuntary participation in gamification features. This brings to the subject of supporting autonomy. Gamification borrows its game mechanics from games and playing games has been pointed out as voluntary (Knaving and Björk, 2013; Seaborn and Fels, 2015). Participating in a gamification layer should be an opt-in (invisible) and not a mandatory in order not to obscure the main activity being promoted (Knaving and Björk, 2013). In most of current gamification designs the line between voluntary and involuntary participation is not clear as a user may voluntarily participate in gamification but may not involuntarily participate in a feature like a leaderboard which may come as part of the package of gamification (Ferro et al., 2013). This brings to the subject of autonomy to users in selecting which of part of gamification features they would like to participate in. In addition to that, there is a different aspect of autonomy that was a shortcoming in this intervention and this is the inability of intermediary users to select the level of gamification appropriate to their skills. The only support for autonomy that was provided is the one that allowed configuration of avatars and editing of team profiles. Intermediaries stated goals as indicated in the findings but never had enough power in accomplishing those goals as the goals largely depended on skills possessed by their respective beneficiaries. Literature suggests approaches on which autonomy could be supported which include but not limited to configuration of profiles, avatars, macros, configurable interface, alternative activities, privacy control, etc. (Francisco et al., 2012). These approaches may scale to the context of technology use through intermediaries but there is a need to explore how intermediary users may have autonomy in formulation and execution of goals to tackle challenges based on their skills. When challenges are too difficult as they don't match users' skills, end users can become demotivated (Zhang, 2008).

Absence of autonomy in formulation and execution of goals may foster negative experiences which appeared to harm intrinsic motivation of some intermediary users in this context. For instance in most cases presence of gamification fostered collaboration between intermediary and beneficiary members of a pair. Out of this collaboration intermediaries were attempting to influence or persuade their respective beneficiaries. In such attempts negative experiences emanated when persuasion was not working. An example of a negative experience is the case of where nudging evolved into nagging like in a scenario we have seen above of **Jenner**, a beneficiary user who described how serious her son was taking the competition with others by constantly reminding her to carry the pedometer whenever she wants to go out and at times the son would get annoyed if his mother forgets to carry the pedometer. The ramification of this is that it deviates from the goal of promoting collaboration between an intermediary user and a beneficiary user and instead it creates a tension between them. In such scenarios intermediary users

may react out frustration of not having control of the skills possessed by their respective beneficiaries; hence this idea of intermediaries to rely solely on skills of their respective beneficiaries seemed not to resonate with the notion of matching challenges to skills of users and it was the main source of tension between members of a pair as highlighted above.

One of the approaches that could be used to minimize the effect of the aforementioned shortcomings is to give users more autonomy to select different levels of gamification they want to participate. There could be levels such as beginners, intermediate, advanced, etc. Pairs that are on the same level could be grouped together and not mixed with pairs with levels that are different. In addition, users could be allowed to select which features they would like to include in their interfaces from a range of features such as chat rooms, leader-boards, botanical gardens etc. More autonomy can also be given in customization of privacy in terms of whether they would like to share their information or not. Customization of avatars is also important because It was observed that most users changed their avatars during gamification and one user explained that she sees the avatar she selected as a representation of herself. Through avatars, these users embodied their identities.

The second possible approach in increasing engagement of intermediary users is to allow intermediary participants to participate with their information, by incorporating their wellness data i.e. steps. The former can also be combined with the latter. There were some observed scenarios that support the utilization of the latter approach. For instance, there was one pair of whereby not only the beneficiary participant was using the pedometer as an intermediary was also using it. They were taking turns to use the pedometer, therefore, they were collaborating in accumulating steps. This pair had discussions of whether the person whose turn it was had walked enough steps. The goal was to accumulate more steps than other pairs. A similar concept has been explored with participants in a low income neighbourhood in USA , of whereby there is an exergame that encourages cooperation between parents and children (Saksono et al., 2015).

A third proposed way of increasing engagement that could be leveraged is the one reflected by intermediaries who claimed to also be benefiting from nutrition/diet information since the same type of meal is shared at home, therefore, if beneficiary participants ate something that is not healthy while at home then there is a likelihood of an intermediary participant to have eaten the same type of meal too. According to literature, parents who live a healthily lifestyle are likely to also influence their children to live healthily (Grimes et al., 2009). Therefore, by creating a system that allows intermediaries to also benefit from usage one can foster internalization through identified and

integrated regulations which are somehow close to intrinsic motivation as these interme-
diaries are going to put more value to the system because of its perceived benefits.

Apart from gamification, another important source of motivation of which one could
leverage is, sharing of phones between participating members of a pair. Beneficiaries
were custodians of intervention's phone. But in many cases when beneficiaries were at
home they left the phone with the intermediaries who were interested with social media
sites and games. Intermediaries were interested with those phones because of either
of the two reasons or both: (1) Interventions phone's were better than intermediaries'
phones or intermediaries didn't have smart phones that can enable to access services they
desire; and (2) Availability of data bundles in intervention's phones through inserted
SIM cards. In these scenarios, some intermediaries were implicitly reciprocating the
favours of having freedom to use the phone by serving requests from their beneficiaries.
In the context of ICTD, non-prescribed use of devices or other technologies allocated
for an intervention is considered to be an aspect of play which is a capability as it
fosters motivation to participate in an intervention (Ferreira, 2015). Therefore, one can
capitalize on this motivation introduced as the result of sharing phones and it can be
viewed as part of motivational affordances to encourage ongoing use of a system through
young intermediaries within family settings. Utilization of the motivational effect of the
phone in mediating such an intervention depends on interest of beneficiaries on the
intervention. Without requests from beneficiaries, and with absence gamification on the
app for intermediaries, the phone effect itself cannot mediate usage of the app unless it
goes in parallel with those two mediating factors for usage.

The last aspect of self-determination worth discussing is perceived relatedness. The
trend of intermediaries users not using social features was recurrent from the previous
chapters. There were face to face interactions outside the context usage logs as it can
noted from some of the excerpts of findings. These interactions were inseparable between
logbook and gamification conditions. One study suggested that social features may be
useful important when users are not collocated Lin et al. (2006). For instance one
intermediary user who was so keen on using social features was not having face to face
interactions with the rest because she didn't get a chance to meet them face to face
apart from the meeting organized by the researcher.

7.4.2 Motivational Affordances' Impact on Beneficiaries

As it has been reported on the findings section, beneficiaries engaged with the app
through intermediaries upon either intermediaries coming to them or beneficiaries putting
a request of something to be done on the app. Requests from beneficiaries were as the

result of being interested in either one of both of the following; (1) leader board, and (2) instrumental value provided by the app. Not all beneficiaries were motivated by gamification. Different strategies are required in order to engage older adults. Literature suggests that emotional stability increases with age (Carstensen et al., 2011); this implies that adults may have a tendency of higher emotional stability compared to children. Gamification may be less effective for people with higher emotional stability. In the previous chapter (Chapter **??**) it was observed that adults cared most about social support from other adults and social comparison increased their perceived relatedness. In this evaluation they were less interactions between beneficiaries; hence less social comparison among beneficiaries alone. Strategies that improve relatedness of beneficiaries may be one way to improve engagement of beneficiaries. Also features that promote task mastery climate may be of interest to this group of participants. For instance one intermediary participant reported that her mother was interested with the botanical garden more than her.

In general the app was perceived well by beneficiaries and gamification was of less importance compared to the perceived value from the app. This is demonstrated by the overall scores of intrinsic motivation inventory (IMI) in self-monitoring of diet and activity. An improvement in IMI score for self-monitoring of diet is significant at endpoint when compared to baseline while for self-monitoring for activity there is an indication of improvement without statistical significance.

7.4.3 Internalization of Helping in Self-Monitoring

The dominance of leaderboard resulted into introjected regulation in most part of where individuals as individuals don't accept a behaviour as of value or of their own rather they merely perform it for the sake of maintaining their self-worth. This had an impact on internalization. Those intermediary users that had no contact with the leaderboard or minimum contact with respect to other gamification features reported to value the intervention as more useful in gamification compared to in in logbook condition. Therefore it is very clear that leaderboard had a tendency of creating an atmosphere of introjected regulation, and this kind of regulation to overshadow the main activity (monitoring of health of beneficiary users) being promoted. A challenging task is to design gamification in such a way it doesn't become the main focus instead of an activity being promoted (Knaving and Björk, 2013).

A leaderboard may be appropriate to some users but it may have a negative effect on some users, and this has already been highlighted on the discussion about personalities and gamer types, and perceived autonomy.

Chapter 8

Conclusions and Future Research

The main research questions were centred around factors that may affect utilization of a personal health informatics through intermediaries, and also the effectiveness of gamification in increasing engagement of intermediaries.**More content on how research questions were addressed**

The most prominent factors are social relationships, support for the two sets of users to achieve an optimal flow, and different requirements for motivation strategies for users from each set. On the effectiveness of gamification, it has demonstrated a potential too increase frequency of usage through intermediaries even though it has some challenges and limitation that need to be addressed.

In this chapter, the focus of discussion is on design considerations for the overall intervention. These design considerations include some of the aforementioned social factors that may contribute to the success of the intervention, and approaches that can be utilized in order to keep both intermediaries and beneficiaries engaged with a personal health informatics system.

8.1   Leverage Family Settings

Informative evaluations revealed that involving children who are family members is the key to success of this intervention. This idea of collaborative interfaces for health information within family settings has been explored in computer supported collaborative work (CSCW) literature. Colineau and Paris (2011) designed a system to support a family to select a collective health goal and receive feedbacks that entailed comparisons between families. Their system was found to encourage members from within a family

or members of different families, to work together and in particular to help each other in finding ways to live a healthily lifestyle.

Family settings provide an idyllic opportunity for members to discuss healthy issues collaboratively. Collaboration between a parent and a child or close family members had a positive impact on child's perception as some intermediaries shared testimonies about their habituation of skills on eating healthy. In addition, intermediaries in some cases logged their data about meals because what they ate was not different from what had been eaten by their respective beneficiaries. A study by Grimes et al. (2009) identified four key areas of consideration in which sharing of, and reflection on, health information can be leveraged within family context as follows: (1) overlaps of routines between family members through shared meals, space, etc which can provide opportunities for collaborative data logging and reflection among family members; (2) sharing is done at the expense of balancing competing values of openness, caring, and modelling with the value of protection; (3) understanding of sensitivity on comparisons and competition based upon health information in the context of the family as it may have negative consequences; and (4) collaborative sharing of, reflecting on, health information can also foster family's bond. In the context of this research, it was evident that the app had increased the bond between participating family members as majority of them claimed that were interacting more often. This is also demonstrated by playfulness behaviours that were exhibited in the process of sharing information as it was shown in one of the excerpt in chapter 6 (Evaluation of Prototype II):

> ' When she got time, when she is done with her homework she comes and sees the app. And then laughs at me like 'Yo yo yo [An interjection for Xhosa speakers to express the feeling of amazement by something] you can walk yo yo yo', like 'you walked a lot today' and what what [She was implying to other words said by Lindiwe]"
>
> —**Zandiwe**, a beneficiary

In existing work from computer supported collaborative work it appears the emphasis is on parents trying to model health behaviors of their children. For a instance in a study by Saksono et al. (2015), a collaborative exergame was developed in order to support both parents and kids to exercise together. Although their goal was to help kids learn from their parents, the collaborative environment was beneficial to both parents and children.

In our case it was peculiar that children were attempting to nudge their parents to live healthily. Therefore, it not only about the parent guiding the child also the child can become a facilitator for guiding the parent about health choices. This was mediated by an existing familial relationship.

Therefore, this work continues to emphasize on the value of familiar relationships in making the collaboration more interesting. Some playful visualization techniques can make the collaboration between two users more enjoyable. In the next section, ways on which one could improve engagement of both sets of users are discussed.

8.2 Sustaining Engagement

In order to enhance user experience, support for factors such as task mastery, support for reflection, enhancement of collaboration within a family (intra-families), or inter-families collaboration are emphasized.

8.2.1 Support for Task Mastery Features

In this work, it was clear that gamification promoted collaboration between participating pairs that had a prior social rapport. In addition, gamification in particular social comparison and competitions, both the one socially construed by users, and the one implemented as an intentional design goal, increase engagement of both intermediary and beneficiary users.

Despite the positive outcomes from gamification, the negative consequences as the results of increased competition have become an area of concern (Jia et al., 2016). It is even more concerning when such competition results into negative consequences in health settings (Grimes et al., 2009). To reduce these negative implications of excessive social comparison and competition, there is an emphasis on supporting challenges on the level of "*task mastery climate*" rather than on competition that has "*ego involved climate*" as the former foster intrinsic motivation while the latter can harm it (Saksono et al., 2015). When "ego is involved", participants may do things just to maintain their self-worth, and this is equivalent to introjected regulation as postulated by organismic integration theory of SDT(Ryan and Deci, 2000b). In introjected regulation individuals don't see a value in regulating a behaviour rather they perform it merely for the purpose of outdoing others or maintaining their social status. For instance, the idea of having a leader board in this intervention encourages competition and it affected motivation of intermediary users who didn't do so well. Features such as fish tank and botanical garden appear to

promote task mastery. For instance in one scenario reported in chapter 6 (Evaluation of Prototype II), a beneficiary user was dissatisfied by the look of their garden.

> *"Nokhanyo saw the garden. The first day she saw just the house and brownish. She is like 'What is this'. I told her. She said 'Aha! [Expressing dissatisfaction]. It must look green and healthy'. And then she saw the garden again and said 'It is looking good."'*
>
> —***Lulama****, an intermediary*

This important finding suggest that such features can encourage task mastery climate. If designers have to use a leaderboard, they need to be cautionary of negative impacts on users' competence despite its ability to foster relatedness (Sailer et al., 2013). Leader board can also result into an extreme competition between intermediaries which can result into a negative impact on a relationship by an intermediaries in cases where an intermediaries feel of being let down by their beneficiaries. Such a scenario is exhibited in the following excerpt on chapter 7 (Summative Evaluation)

> *"Sometimes may be I forget to take the phone when I go walking and he would ask me 'did you take the phone with you' Ooh Gosh I forgot. Because when I walk to Park Town to exercise and sometimes I am in such a hurry I forget the phone, he will be crossed with me."*
>
> —***Jenner****, a female beneficiary from Athlone, 45 yrs old*

In the aforementioned case, an intermediary got angry because of her mother tendency of forgetting to take the pedometer (phone) when she goes out for walking. Therefore this highlights the importance of paying more attention should on features that support task mastery climate.

8.3 Long-term Benefits of Personalized Apps for Health

Long term usage and prolonged benefits of personalized apps are still debatable. One study that a conducted a two years trials that compared among three strategies: interactive smartphone application on a cell phone (CP); personal coaching enhanced by smartphone self-monitoring (PC); or handout (pamphlets) as the control group found that smart-phone to be better than control in short time but in long term the results were not different (Svetkey et al., 2015). It is argued that usage of these apps should go hand in hand with other conventional strategies. In addition, long term engagement is a key challenge in personalized apps for health. Once the novelty effect is worn out

users may tend to revert to their old habits. Gamification is not exceptional when it comes to the issue of the novelty effect. In the context of intermediated technology it may even be more challenging in sustaining engagement. This is still a grey area that needs further exploration.

Bibliography

Nithya Sambasivan, Ed Cutrell, Kentaro Toyama, and Bonnie Nardi. Intermediated technology use in developing communities. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 2583–2592. ACM, April 2010.

Richard M Ryan and Edward L Deci. Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary educational psychology*, 25(1):54–67, 2000a.

Ntwa Katule, Melissa Densmore, and Ulrike Rivett. Leveraging intermediated interactions to support utilization of persuasive personal health informatics. In *Proceedings of the Eighth International Conference on Information and Communication Technologies and Development*, page 19. ACM, 2016.

Daphne P Guh, Wei Zhang, Nick Bansback, Zubin Amarsi, C Laird Birmingham, and Aslam H Anis. The incidence of co-morbidities related to obesity and overweight: a systematic review and meta-analysis. *BMC public health*, 9(1):1, 2009.

K Steyn, J Fourie, and N Temple. Chronic diseases of lifestyle in south africa: 1995-2005. *Cape Town: South African Medical Research Council*, pages 33–47, 2006.

Dele O. Abegunde, Colin D. Mathers, Taghreed Adam, Monica Ortegon, and Kathleen Strong. The burden and costs of chronic diseases in low-income and middle-income countries. *The Lancet*, 370(960 Burton Baraga3):1929–1938, December 2007.

John Pollak, Geri Gay, Sahara Byrne, Emily Wagner, Daniela Retelny, and Lee Humphreys. It's time to eat! using mobile games to promote healthy eating. *IEEE Pervasive Computing*, 9(3):21–27, 2010.

Charlene C Quinn, Suzanne Sysko Clough, James M Minor, Dan Lender, Maria C Okafor, and Ann Gruber-Baldini. Welldoc™ mobile diabetes management randomized controlled trial: change in clinical and behavioral outcomes and patient and physician satisfaction. *Diabetes technology & therapeutics*, 10(3):160–168, 2008.

Eirik Årsand, Dag Helge Frøisland, Stein Olav Skrøvseth, Taridzo Chomutare, Naoe Tatara, Gunnar Hartvigsen, and James T Tufano. Mobile health applications to assist

patients with diabetes: lessons learned and design implications. *Journal of diabetes science and technology*, 6(5):1197–1206, 2012.

Ilkka Korhonen, Elina M Mattila, and Mark vam Gils. Personal health systems-opportunities and barriers for adoption. In *2010 Annual International Conference of the IEEE Engineering in Medicine and Biology*, pages 5272–5272. IEEE, 2010.

John P Higgins. Smartphone applications for patients' health and fitness. *The American journal of medicine*, 129(1):11–19, 2016.

Yu Chen and Pearl Pu. Healthytogether: exploring social incentives for mobile fitness applications. In *Proceedings of the Second International Symposium of Chinese CHI*, pages 25–34. ACM, 2014.

Eirik Årsand, Naoe Tatara, Gunnar Hartvigsen, et al. Mobile phone-based self-management tools for type 2 diabetes: the few touch application. *Journal of diabetes science and technology*, 4(2):328–336, March 2010.

Anne Hsu, Jing Yang, Yigit Han Yilmaz, Md Sanaul Haque, Cengiz Can, and Ann E. Blandford. Persuasive technology for overcoming food cravings and improving snack choices. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 3403–3412. ACM, April 2014.

Elina Mattila, Juha Pärkkä, Marion Hermersdorf, Jussi Kaasinen, Janne Vainio, Kai Samposalo, Juho Merilahti, Juha Kolari, Minna Kulju, Raimo Lappalainen, et al. Mobile diary for wellness management—results on usage and usability in two user studies. *IEEE Transactions on information technology in biomedicine*, 12(4):501–512, 2008.

Marsha J Handel. mhealth (mobile health)—using apps for health and wellness. *EXPLORE: The Journal of Science and Healing*, 7(4):256–261, 2011.

Yevgeniy Medynskiy and Elizabeth Mynatt. Salud!: An open infrastructure for developing and deploying health self-management applications. In *Pervasive Computing Technologies for Healthcare (PervasiveHealth), 2010 4th International Conference on*, pages 1–8. IEEE, March 2010.

Sunny Consolvo, Predrag Klasnja, David W McDonald, and James A Landay. Goal-setting considerations for persuasive technologies that encourage physical activity. In *Proceedings of the 4th international Conference on Persuasive Technology*, page 8. ACM, 2009.

Heather Cole-Lewis and Trace Kershaw. Text messaging as a tool for behavior change in disease prevention and management. *Epidemiologic reviews*, 32(1):56–69, 2010.

Juho Hamari, Jonna Koivisto, and Tuomas Pakkanen. Do persuasive technologies persuade?-a review of empirical studies. In *Persuasive Technology*, pages 118–136. Springer, May 2014a.

Juho Hamari, Jonna Koivisto, and Harri Sarsa. Does gamification work?-a literature review of empirical studies on gamification. In *System Sciences (HICSS), 2014 47th Hawaii International Conference on*, pages 3025–3034. IEEE, January 2014b.

Warren A. Kaplan. Can the ubiquitous power of mobile phones be used to improve health outcomes in developing countries? *Globalization and health*, 2(1):1, May 2006.

Neha Kumar and Richard J Anderson. Mobile phones for maternal health in rural india. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, pages 427–436. ACM, 2015.

Victor Kaptelinin and Bonnie A Nardi. Activity theory: basic concepts and applications. In *CHI'97 Extended Abstracts on Human Factors in Computing Systems*, pages 158–159. ACM, 1997.

Tatsuo Nakajima and Vili Lehdonvirta. Designing motivation using persuasive ambient mirrors. *Personal and ubiquitous computing*, 17(1):107–126, 2013.

Brian J Fogg. Persuasive technologies. *Communications of the ACM*, 42(5):27–29, 1999.

Sitwat Langrial. From digital interventions to behavior change support systems: Understanding persuasive systems' development and evaluation process. In *Proceedings of IRIS*, pages 1–16, 2012.

Harri Oinas-Kukkonen. A foundation for the study of behavior change support systems. *Personal and ubiquitous computing*, 17(6):1223–1235, August 2013.

Harri Oinas-Kukkonen and Marja Harjumaa. Persuasive systems design: Key issues, process model, and system features. *Communications of the Association for Information Systems*, 24(1):485–500, March 2009.

Brian J Fogg. A behavior model for persuasive design. In *Proceedings of the 4th international Conference on Persuasive Technology*, page 40. ACM, 2009a.

BJ Fogg. The behavior grid: 35 ways behavior can change. In *Proceedings of the 4th international Conference on Persuasive Technology*, page 42. ACM, 2009b.

Samir Chatterjee and Alan Price. Healthy living with persuasive technologies: framework, issues, and challenges. *Journal of the American Medical Informatics Association*, 16(2):171–178, March 2009.

Brianna S Fjeldsoe, Alison L Marshall, and Yvette D Miller. Behavior change interventions delivered by mobile telephone short-message service. *American journal of preventive medicine*, 36(2):165–173, 2009.

Santosh Krishna, Suzanne Austin Boren, and E Andrew Balas. Healthcare via cell phones: a systematic review. *Telemedicine and e-Health*, 15(3):231–240, 2009.

Laura P Svetkey, Bryan C Batch, Pao-Hwa Lin, Stephen S Intille, Leonor Corsino, Crystal C Tyson, Hayden B Bosworth, Steven C Grambow, Corrine Voils, Catherine Loria, et al. Cell phone intervention for you (city): A randomized, controlled trial of behavioral weight loss intervention for young adults using mobile technology. *Obesity*, 23(11):2133–2141, 2015.

Simon McCallum. Gamification and serious games for personalized health. *Stud Health Technol Inform*, 177:85–96, 2012.

Ian Li, Anind Dey, Jodi Forlizzi, Kristina Höök, and Yevgeniy Medynskiy. Personal informatics and hci: design, theory, and social implications. In *CHI'11 Extended Abstracts on Human Factors in Computing Systems*, pages 2417–2420. ACM, 2011a.

Ian Li, Yevgeniy Medynskiy, Jon Froehlich, and Jakob Larsen. Personal informatics in practice: improving quality of life through data. In *CHI'12 Extended Abstracts on Human Factors in Computing Systems*, pages 2799–2802. ACM, 2012.

Ian Li, Anind Dey, and Jodi Forlizzi. A stage-based model of personal informatics systems. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 557–566. ACM, 2010.

Rob Comber and Anja Thieme. Designing beyond habit: opening space for improved recycling and food waste behaviors through processes of persuasion, social influence and aversive affect. *Personal and ubiquitous computing*, 17(6):1197–1210, 2013.

Clive Seligman and John M Darley. Feedback as a means of decreasing residential energy consumption. *Journal of Applied Psychology*, 62(4):363, 1977.

Ian Li, Anind K Dey, and Jodi Forlizzi. Understanding my data, myself: supporting self-reflection with ubicomp technologies. In *Proceedings of the 13th international conference on Ubiquitous computing*, pages 405–414. ACM, 2011b.

Predrag V Klasnja, Sunny Consolvo, David W McDonald, James A Landay, and Wanda Pratt. Using mobile & personal sensing technologies to support health behavior change in everyday life: lessons learned. Citeseer, 2009.

James J Lin, Lena Mamykina, Silvia Lindtner, Gregory Delajoux, and Henry B Strub. Fish'n'steps: Encouraging physical activity with an interactive computer game. In *UbiComp 2006: Ubiquitous Computing*, pages 261–278. Springer, 2006.

NOEI NIH, Lung National Heart, Blood Institute, North American Association for the Study of Obesity, et al. The practical guide identification, evaluation, and treatment of overweight and obesity in adults.". *NIH Publication Number DO-4084*, pages 35–38, 2000.

Amon Rapp. Meaningful game elements for personal informatics. In *Proceedings of the 2014 ACM International Symposium on Wearable Computers: Adjunct Program*, pages 125–130. ACM, 2014.

Sonia Arteaga. Persuasive mobile exercise companion for teenagers with weight management issues. *ACM SIGACCESS Accessibility and Computing*, (96):4–10, 2010.

PJ Burns, Christopher Lueg, and Shlomo Berkovsky. Using personal informatics to motivate physical activity: could we be doing it wrong? In *Chi 2012 workshop*, pages 1–4, 2012.

Gunny Lee, Chris Tsai, William G Griswold, Fred Raab, and Kevin Patrick. Pmeb: a mobile phone application for monitoring caloric balance. In *CHI'06 Extended Abstracts on Human Factors in Computing Systems*, pages 1013–1018. ACM, 2006.

Noreen Kamal, Fels Sidney, and Ho Kendall. Online social networks for personal informatics to promote positive health behavior. In *Proceedings of second ACM SIGMM workshop on Social media*, pages 47–52. ACM, October 2010.

Haley MacLeod, Anthony Tang, and Sheelagh Carpendale. Personal informatics in chronic illness management. In *Proceedings of Graphics Interface 2013*, pages 149–156. Canadian Information Processing Society, 2013.

Daniel A Epstein, An Ping, James Fogarty, and Sean A Munson. A lived informatics model of personal informatics. In *Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing*, pages 731–742. ACM, 2015a.

Sean Munson. Mindfulness, reflection, and persuasion in personal informatics. 2012.

Brian J. Fogg. *Persuasive Technology: Using Computers to Change What We Think and Do.*, chapter 5, pages 89–120. Morgan Kaufmann, 2003.

Brian J. Fogg. Persuasive computers: perspectives and research directions. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 225–232. ACM Press/Addison-Wesley Publishing Co., January 1998.

Dena M Bravata, Crystal Smith-Spangler, Vandana Sundaram, Allison L Gienger, Nancy Lin, Robyn Lewis, Christopher D Stave, Ingram Olkin, and John R Sirard. Using pedometers to increase physical activity and improve health: a systematic review. *Jama*, 298(19):2296–2304, 2007.

Iñaki Merino Albaina, Thomas Visser, Charles APG van der Mast, and Martijn H Vastenburg. Flowie: A persuasive virtual coach to motivate elderly individuals to walk. In *2009 3rd International Conference on Pervasive Computing Technologies for Healthcare*, pages 1–7. IEEE, 2009.

Victor J. Strecher, Gerard H. Seijts, Gerjo J. Kok, Gary P. Latham, Russell Glasgow, Brenda DeVellis, Ree M. Meertens, and David W. Bulger. Goal setting as a strategy for health behavior change. *Health Education & Behavior*, 22(2):190–200, July 1995.

Pascal Lessel, Maximilian Altmeyer, Frederic Kerber, Michael Barz, Cornelius Leidinger, and Antonio Krüger. Watercoaster: A device to encourage people in a playful fashion to reach their daily water intake level. In *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems*, pages 1813–1820. ACM, 2016.

Chloe Fan, Jodi Forlizzi, and Anind K Dey. A spark of activity: exploring informative art as visualization for physical activity. In *Proceedings of the 2012 ACM Conference on Ubiquitous Computing*, pages 81–84. ACM, 2012.

Bernd Ploderer, Wolfgang Reitberger, Harri Oinas-Kukkonen, and Julia van Gemert-Pijnen. Social interaction and reflection for behaviour change. *Personal and ubiquitous computing*, 18(7):1667–1676, 2014.

Yu Chen, Mirana Randriambelonoro, Antoine Geissbuhler, and Pearl Pu. Social incentives in pervasive fitness apps for obese and diabetic patients. In *Proceedings of the 19th ACM Conference on Computer Supported Cooperative Work and Social Computing Companion*, pages 245–248. ACM, 2016.

Daniel A Epstein, Bradley H Jacobson, Elizabeth Bales, David W McDonald, and Sean A Munson. From nobody cares to way to go!: A design framework for social sharing in personal informatics. In *Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing*, pages 1622–1636. ACM, 2015b.

Corbin Reno and Erika S Poole. It matters if my friends stop smoking: Social support for behavior change in social media. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, pages 5548–5552. ACM, 2016.

Teng Han, Lanfei Shi, Xiang Xiao, John Canny, and Jingtao Wang. Designing engaging camera based mobile games for implicit heart rate monitoring. In *Proceedings of the*

extended abstracts of the 32nd annual ACM conference on Human factors in computing systems, pages 1675–1680. ACM, 2014.

Rob Comber, Anja Thieme, Ashur Rafiev, Nick Taylor, Nicole Krämer, and Patrick Olivier. Bincam: Designing for engagement with facebook for behavior change. In *IFIP Conference on Human-Computer Interaction*, pages 99–115. Springer, 2013.

Elizabeth Bales and William Griswold. Interpersonal informatics: making social influence visible. In *CHI'11 Extended Abstracts on Human Factors in Computing Systems*, pages 2227–2232. ACM, 2011.

JS Parikh and Kaushik Ghosh. Understanding and designing for intermediated information tasks in india. *Pervasive Computing, IEEE*, 5(2):32–39, April 2006.

Savita Bailur. The liminal role of the information intermediary in community multimedia centres. In *Proceedings of the 4th ACM/IEEE International Conference on Information and Communication Technologies and Development*, page 5. ACM, 2010.

Richard Heeks. The tyranny of participation in information systems: Learning from development projects, 1999.

Savita Bailur and Silvia Masiero. The complex position of the intermediary in telecenters and community multimedia centers. *Information Technologies & International Development*, 8(1):pp–27, 2012.

Ricardo Ramírez, Balaji Parthasarathy, and Andrew Gordon. From infomediaries to infomediation at public access venues: Lessons from a 3-country study. In *Proceedings of the Sixth International Conference on Information and Communication Technologies and Development: Full Papers-Volume 1*, pages 124–132. ACM, December 2013.

Nithya Sambasivan and Thomas Smyth. The human infrastructure of ictd. In *Proceedings of the 4th ACM/IEEE International Conference on Information and Communication Technologies and Development*, page 40. ACM, 2010.

Matthew R Jones and Helena Karsten. Giddens's structuration theory and information systems research. *MIS quarterly*, 32(1):127–157, 2008.

Abhay Sukumaran, Satyan Ramlal, Eyal Ophir, Vangala RamNaresh Kumar, Gaurav Mishra, Vanessa Evers, Venkataraman Balaji, and Clifford Nass. Intermediated technology interaction in rural contexts. In *CHI'09 Extended Abstracts on Human Factors in Computing Systems*, pages 3817–3822. ACM, April 2009.

Erika Shehan Poole, Marshini Chetty, Tom Morgan, Rebecca E Grinter, and W Keith Edwards. Computer help at home: methods and motivations for informal technical

support. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 739–748. ACM, April 2009.

Divya Ramachandran, John Canny, Prabhu Dutta Das, and Edward Cutrell. Mobileizing health workers in rural india. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 1889–1898. ACM, April 2010a.

Divya Ramachandran, Vivek Goswami, and John Canny. Research and reality: using mobile messages to promote maternal health in rural india. In *Proceedings of the 4th ACM/IEEE International Conference on Information and Communication Technologies and Development*, page 35. ACM, December 2010b.

Maletsabisa Molapo and Gary Marsden. Software support for creating digital health training materials in the field. In *Proceedings of the Sixth International Conference on Information and Communication Technologies and Development: Full Papers-Volume 1*, pages 205–214. ACM, December 2013.

Aditya Vashistha, Neha Kumar, Anil Mishra, and Richard Anderson. Mobile video dissemination for community health. In *Proceedings of the Eighth International Conference on Information and Communication Technologies and Development*, page 20. ACM, 2016.

Sara Kiesler, Bozena Zdaniuk, Vicki Lundmark, and Robert Kraut. Troubles with the internet: The dynamics of help at home. *Human-Computer Interaction*, 15(4):323–351, December 2000.

Younghwa Lee, Jintae Lee, and Yujong Hwang. Relating motivation to information and communication technology acceptance: Self-determination theory perspective. *Computers in Human Behavior*, 51:418–428, 2015.

Edward L Deci and Richard M Ryan. *Intrinsic motivation and self-determination in human behavior*. Springer Science & Business Media, 1985a.

Richard M Ryan and Edward L Deci. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American psychologist*, 55 (1):68, 2000b.

Ping Zhang. Technical opinion motivational affordances: reasons for ict design and use. *Communications of the ACM*, 51(11):145–147, 2008.

Nathalie Colineau and Cécile Paris. Motivating reflection about health within the family: the use of goal setting and tailored feedback. *User Modeling and User-Adapted Interaction*, 21(4-5):341–376, 2011.

Seamus F Forde, Elisa D Mekler, and Klaus Opwis. Informational vs. controlling gamifi-
cation: A study design. In *Proceedings of the 2015 Annual Symposium on Computer-
Human Interaction in Play*, pages 517–522. ACM, 2015.

Richard M Ryan, C Scott Rigby, and Andrew Przybylski. The motivational pull of
video games: A self-determination theory approach. *Motivation and emotion*, 30(4):
344–360, 2006.

Thomas G Power, Sarah C Ullrich-French, Michael M Steele, Kenn B Daratha, and
Ruth C Bindler. Obesity, cardiovascular fitness, and physically active adolescents'
motivations for activity: A self-determination theory approach. *Psychology of Sport
and Exercise*, 12(6):593–598, 2011.

Geoffrey C Williams, Holly A McGregor, Daryl Sharp, Chantal Levesque, Ruth W
Kouides, Richard M Ryan, and Edward L Deci. Testing a self-determination theory
intervention for motivating tobacco cessation: supporting autonomy and competence
in a clinical trial. *Health Psychology*, 25(1):91, 2006.

Dave Webb, Geoffrey N Soutar, Tim Mazzarol, and Patricia Saldaris. Self-determination
theory and consumer behavioural change: Evidence from a household energy-saving
behaviour study. *Journal of Environmental Psychology*, 35:59–66, 2013.

Kristina Knaving and Staffan Björk. Designing for fun and play: exploring possibilities
in design for gamification. In *Proceedings of the First International Conference on
Gameful Design, Research, and Applications*, pages 131–134. ACM, 2013.

Kellie Vella, Daniel Johnson, and Leanne Hides. Positively playful: when videogames
lead to player wellbeing. In *Proceedings of the First International Conference on
Gameful Design, Research, and Applications*, pages 99–102. ACM, 2013.

Sebastian Deterding, Dan Dixon, Rilla Khaled, and Lennart Nacke. From game design
elements to gamefulness: defining gamification. In *Proceedings of the 15th Inter-
national Academic MindTrek Conference: Envisioning Future Media Environments*,
pages 9–15. ACM, September 2011.

Chris Preist and Robert Jones. The use of games as extrinisic motivation in education.
In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing
Systems*, pages 3735–3738. ACM, 2015.

Katie Seaborn and Deborah I Fels. Gamification in theory and action: A survey. *Inter-
national Journal of Human-Computer Studies*, 74:14–31, 2015.

Michael Sailer, Jan Hense, Heinz Mandl, and Markus Klevers. Psychological perspectives
on motivation through gamification. *Interaction Design and Architecture(s)*, 19:28–37,
2013.

Juho Hamari and Jonna Koivisto. Social motivations to use gamification: An empirical study of gamifying exercise. In *ECIS*, page 105.

Elisa D Mekler, Florian Brühlmann, Klaus Opwis, and Alexandre N Tuch. Do points, levels and leaderboards harm intrinsic motivation?: an empirical analysis of common gamification elements. In *Proceedings of the First International Conference on gameful design, research, and app@articlenicholson2012user, title=A user-centered theoretical framework for meaningful gamification, author=Nicholson, Scott, journal=Games+ Learning+ Society, volume=8, number=1, pages=223-230, year=2012 lications*, pages 66–73. ACM, 2013a.

Edward L Deci, Haleh Eghrari, Brian C Patrick, and Dean R Leone. Facilitating internalization: The self-determination theory perspective. *Journal of personality*, 62(1): 119–142, 1994.

Scott Nicholson. A user-centered theoretical framework for meaningful gamification. *Games+ Learning+ Society*, 8(1):223–230, 2012.

Elisa D Mekler, Florian Brühlmann, Klaus Opwis, and Alexandre N Tuch. Disassembling gamification: the effects of points and meaning on user motivation and performance. In *CHI'13 extended abstracts on human factors in computing systems*, pages 1137–1142. ACM, 2013b.

Dominic King, Felix Greaves, Christopher Exeter, and Ara Darzi. 'gamification': Influencing health behaviours with games. *Journal of the Royal Society of Medicine*, 106 (3):76–78, 2013.

Yoonsin Oh and Stephen Yang. Defining exergames & exergaming. *Proceedings of Meaningful Play*, pages 1–17, 2010.

Lee EF Graves, Nicola D Ridgers, Karen Williams, Gareth Stratton, and Greg T Atkinson. The physiological cost and enjoyment of wii fit in adolescents, young adults, and older adults. *Journal of physical activity & health*, 7(3):393–401, 2010.

Debra A Lieberman. Dance games and other exergames: What the research says. 2006.

Stefan Göbel, Sandro Hardy, Viktor Wendel, Florian Mehm, and Ralf Steinmetz. Serious games for health: personalized exergames. In *Proceedings of the 18th ACM international conference on Multimedia*, pages 1663–1666. ACM, 2010.

Clare Southerton. Zombies, run!': Rethinking immersion in light of nontraditional gaming contexts. *Transmedia: Storytelling and Beyond Digital Interfaces*, 2013.

Carl J Caspersen, Kenneth E Powell, and Gregory M Christenson. Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public health reports*, 100(2):126, 1985.

Yuichi Fujiki, Konstantinos Kazakos, Colin Puri, Pradeep Buddharaju, Ioannis Pavlidis, and James Levine. Neat-o-games: blending physical activity and fun in the daily routine. *Computers in Entertainment (CIE)*, 6(2):21, 2008.

Jan David Smeddinck, Marc Herrlich, and Rainer Malaka. Exergames for physiotherapy and rehabilitation: A medium-term situated study of motivational aspects and impact on functional reach. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, pages 4143–4146. ACM, 2015.

Shlomo Berkovsky, Jill Freyne, and Mac Coombe. Physical activity motivating games: be active and get your own reward. *ACM Transactions on Computer-Human Interaction (TOCHI)*, 19(4):32, 2012.

Ellen Brox, Luis Fernandez Luque, G Evertsen, and Juan Emilio González Hernández. Exergames for elderly. *Social exergames to persuade seniors to increase physical activity, UbiTheraGames, Dublin*, pages 23–26, 2011.

Philipp Brauner, André Calero Valdez, Ulrik Schroeder, and Martina Ziefle. Increase physical fitness and create health awareness through exergames and gamification. In *Human Factors in Computing and Informatics*, pages 349–362. Springer, 2013.

Paula Alexandra Silva, Kelly Holden, and Aska Nii. Smartphones, smart seniors, but not-so-smart apps: A heuristic evaluation of fitness apps. In *Foundations of Augmented Cognition. Advancing Human Performance and Decision-Making through Adaptive Systems*, pages 347–358. Springer, June 2014.

Andrea Grimes, Desney Tan, and Dan Morris. Toward technologies that support family reflections on health. In *Proceedings of the ACM 2009 international conference on Supporting group work*, pages 311–320. ACM, 2009.

Herman Saksono, Ashwini Ranade, Geeta Kamarthi, Carmen Castaneda-Sceppa, Jessica A Hoffman, Cathy Wirth, and Andrea G Parker. Spaceship launch: Designing a collaborative exergame for families. In *Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing*, pages 1776–1787. ACM, 2015.

Tim Marsh. Serious games continuum: Between games for purpose and experiential environments for purpose. *Entertainment Computing*, 2(2):61–68, 2011.

Shlomo Berkovsky, Mac Coombe, Jill Freyne, Dipak Bhandari, and Nilufar Baghaei. Physical activity motivating games: virtual rewards for real activity. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 243–252. ACM, 2010.

James A Levine, Mark W Vander Weg, James O Hill, and Robert C Klesges. Non-exercise activity thermogenesis the crouching tiger hidden dragon of societal weight gain. *Arteriosclerosis, thrombosis, and vascular biology*, 26(4):729–736, 2006.

Greg Walsh and Jennifer Golbeck. Stepcity: a preliminary investigation of a personal informatics-based social game on behavior change. In *CHI'14 Extended Abstracts on Human Factors in Computing Systems*, pages 2371–2376. ACM, 2014.

Joseph A Cafazzo, Mark Casselman, Nathaniel Hamming, Debra K Katzman, and Mark R Palmert. Design of an mhealth app for the self-management of adolescent type 1 diabetes: a pilot study. *Journal of medical Internet research*, 14(3):e70, May 2012.

Rita Orji, Julita Vassileva, and Regan L Mandryk. Lunchtime: a slow-casual game for long-term dietary behavior change. *Personal and Ubiquitous Computing*, 17(6): 1211–1221, 2013a.

Teng Han, Xiang Xiao, Lanfei Shi, John Canny, and Jingtao Wang. Balancing accuracy and fun: Designing camera based mobile games for implicit heart rate monitoring. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, pages 847–856. ACM, 2015.

David Premack. Toward empirical behavior laws: I. positive reinforcement. *Psychological review*, 66(4):219, 1959.

Kacie CA Blackman, Jamie Zoellner, D Scott McCrickard, Judith Harlow, Woodrow W Winchester III, Jennie L Hill, Wen You, and Paul A Estabrooks. Developing mobile apps for physical activity in low socioeconomic status youth. *Journal of Mobile Technology in Medicine*, 5(1):33–44, 2016.

Matthew Kam, Aishvarya Agarwal, Anuj Kumar, Siddhartha Lal, Akhil Mathur, Anuj Tewari, and John Canny. Designing e-learning games for rural children in india: a format for balancing learning with fun. In *Proceedings of the 7th ACM conference on Designing interactive systems*, pages 58–67. ACM, February 2008.

Adele Botha and Marlien Herselman. Icts in rural education: Let the game begin. In *Proceedings of the 2015 Annual Symposium on Computing for Development*, pages 105–113. ACM, December 2015.

Boyd A Swinburn, Ian Caterson, Jaap C Seidell, and WPT James. Diet, nutrition and the prevention of excess weight gain and obesity. *Public health nutrition*, 7(1a): 123–146, 2004.

Claude Bouchard, Jean-Pierre Depres, and Angelo Tremblay. Exercise and obesity. *Obesity research*, 1(2):133–147, 1993.

Jennifer C Collins and Jon E Bentz. Behavioral and psychological factors in obesity. *The Journal of Lancaster General Hospital*, 4(4):124–127, 2009.

Ian Janssen, Peter T Katzmarzyk, and Robert Ross. Waist circumference and not body mass index explains obesity-related health risk. *The American journal of clinical nutrition*, 79(3):379–384, 2004.

LJ De Groot, P Beck-Peccoz, G Chrousos, K Dungan, A Grossman, JM Hershman, C Koch, R McLachlan, M New, R Rebar, et al. Clinical problems caused by obesity-endotext. 2000.

G D Dinsa, Y Goryakin, E Fumagalli, and M Suhrcke. Obesity and socioeconomic status in developing countries: a systematic review. *Obesity reviews*, 13(11):1067–1079, November 2012.

Aus Tariq Ali and Nigel J. Crowther. Factors predisposing to obesity: a review of the literature. *Journal of Endocrinology, Metabolism and Diabetes of South Africa*, 14(2), 2009.

James O Hill and John C Peters. Environmental contributions to the obesity epidemic. *Science*, 280(5368):1371–1374, 1998.

Marie Ng, Tom Flemming, Margaret Robinson, Blake Thomson, Nicholas Graetz, Christopher Margono, Erin C.Mullany, Stan Biryukov, Cristiana Abbafati, and Semaw Ferede Abera. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980-2013: a systematic analysis for the global burden of disease study 2013. *The Lancet*, 384(9945):766–781, September 2014.

S Benatar. The challenges of health disparities in south africa. *SAMJ: South African Medical Journal*, 103(3):154–155, 2013.

Sandra A Vannoy and Prashant Palvia. The social influence model of technology adoption. *Communications of the ACM*, 53(6):149–153, 2010.

Edward L Deci and Richard M Ryan. *Intrinsic motivation and self-determination in human behavior*. Springer Science & Business Media, 1985b.

Yuan Jia, Bin Xu, Yamini Karanam, and Stephen Voida. Personality-targeted gamification: A survey study on personality traits and motivational affordances. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, pages 2001–2013. ACM, 2016.

Lauren S Ferro, Steffen P Walz, and Stefan Greuter. Towards personalised, gamified systems: an investigation into game design, personality and player typologies. In *Proceedings of The 9th Australasian Conference on Interactive Entertainment: Matters of Life and Death*, page 7. ACM, 2013.

Rita Orji, Regan L Mandryk, Julita Vassileva, and Kathrin M Gerling. Tailoring persuasive health games to gamer type. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 2467–2476. ACM, 2013b.

Andrés Francisco, Francisco Luis, J Gonzalez, and J Isla. Analysis and application of gamification, 2012.

Pedro Ferreira. Why play? examining the roles of play in ictd. *Aarhus Series on Human Centered Computing*, 1(1):12, October 2015.

Laura L Carstensen, Bulent Turan, Susanne Scheibe, Nilam Ram, Hal Ersner-Hershfield, Gregory R Samanez-Larkin, Kathryn P Brooks, and John R Nesselroade. Emotional experience improves with age: evidence based on over 10 years of experience sampling. *Psychology and aging*, 26(1):21, 2011.