Designing Culture-Tailored Persuasive Technology to Promote Physical Activity

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Abstract

Physical inactivity has been recognized as one of the leading risk factors that account for cardiovascular disease, type-2 diabetes, stroke, hypertension, etc., with the World Health Organization labeling it as the fourth leading risk factor for global mortality. Research has shown that persuasive technology (PT) can be leveraged as a motivational/supportive tool in tackling the physical-inactivity problem. In particular, research shows that persuasive health applications (PHAs) are more likely to be effective if they are theory-driven and tailored to the target audience. Yet, most existing PHAs on the market are neither theory-driven nor tailored to the target audience. Rather, their designers often employ a one-size-fits-all approach. This makes it difficult to know what design decisions are effective or ineffective among a given target audience. To bridge this gap, I proposed a framework, called the "EMVE-DeCK Framework," grounded in Bandura's Triad of Reciprocal Determinism, for designing, implementing and evaluating tailored PT interventions. Basically, the EMVE-DeCK Framework employs "Theory" and "Technology" to *explain* and *change* "Behavior."

Moreover, research shows that culture can be leveraged as a personalization mechanism for tailoring PHAs to the target users to make them more effective. However, there is limited cross-cultural research—grounded in theory and empirical evidence—on the effectiveness of culture-based tailoring, especially comparative studies involving understudied populations in the PT research landscape. Hence, using the Hofstede's cultural framework (individualism vs. collectivism), Social Cognitive Theory, Technology Acceptance Model and the EMVE-DeCK Framework, I conducted a number of comparative studies to understand the culture-specific determinants of physical-activity behavior and the acceptance of a proposed PHA. I used the findings to inform the design, implementation and evaluation of two versions of a fitness app called BEN'FIT—personal version (PV) and social version (SV)—aimed to motivate bodyweight exercise at home.

In this dissertation, using the EMVE-DeCK Framework and Canada/United States (individualist culture) and Nigeria (collectivist culture) as a case study, I describe: (1) the cross-cultural user studies and empirical findings that informed the PT intervention; (2) the design and implementation of the culture-tailored PHA; (3) the evaluation of the overall and culture-tailoring effectiveness of the PHA in a field setting. Finally, based on empirical evidence, I present a set of validated PT design guidelines in the field for designing and tailoring PHAs to users in the individualist and collectivist cultures.

This dissertation makes three major contributions to PT research in the Human-Computer-Interaction domain. Firstly, it demonstrates how theory and culture can be employed in the design and development of PT interventions to motivate behavior change. Secondly, it reveals and validates in the field how the individualist and collectivist cultures fundamentally differ in their motivational mechanism of behavior change. Thirdly, it provides an in-the-field validates PT design guidelines for developing tailored PHAs for the two main types of culture. In the physical-activity domain, the dissertation is the first to conduct a theory-driven, in-the-field cross-cultural PT research that focuses on an understudied population from Africa (Nigeria) and compare its findings with those of a widely studied population from North America (Canada/United States).

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for Esivwename

Contents

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List of Abbreviations

ANOVA	Analysis of Variance
AEST	Perceived Aesthetics
CAD	Canadian Dollar
CMPT	Competition
COL (C)	Collectivist Culture
COOP	Cooperation
CRED	Perceived Credibility
CV	Control Version
DSRM	Design Science Research Method
ENV	Physical Environment
GOAL/SMT	Goal-Setting/Self-Monitoring
GOOD	Perceived Goodness
GOF	Goodness of Fit
HCI	Human Computer Interaction
IND (I)	Individualist Culture
ITU	Intention to Use
KF	Key Feature
MET	Metabolism Equivalent of Task
N	Nigerian Naira
NCD	Non-Communicable Disease
OE	Outcome Expectation
PA	Physical Activity
PAL	Physical Activity Level
PERS	Perceived Persuasiveness
PHA	Persuasive Health Application
PLSPM	Partial Least Square Path Modeling
PT	Persuasive Technology
PTAM	Persuasive Technology Acceptance Model
PTUM	Persuasive Technology User Model
PV	Personal Version
R^2	Coefficient of Determination
REWD	Reward
RQ	Research Question
SCOMP	Social Comparison
SCT	Social Cognitive Theory
SE	Self-Efficacy
SEM	Structural Equation Model
SLEARN	Social Learning
SR	Self-Regulation
SS	Social Support
SV	Social Version
TAM	Technology Acceptance Model
UI	User Interface
US	United States
USAB	Perceived Usability
USEF	Perceived Usefulness
UX	User Experience
WHO	World Health Organization
β	Direct Effect (Path Coefficient)
β_T	Total Effect

1 Introduction

Physical inactivity has been identified as a major threat to the health and well-being of human beings globally, regardless of gender, age, culture, income, education, to mention just a few [1]. It has been identified as the fourth leading risk factor for death worldwide [2]. Particularly, it accounts for about 6% of global mortality [3]. According to World Health Organization (WHO) [4], *1 in 4 adults, and 3 in 4 adolescents (aged 11–17 years), do not currently meet the global recommendations for physical activity set by WHO"* (p. 6). In other words, people are unable to meet the WHO's guideline of 600 Metabolic Equivalent of Task (MET[1]) minutes of physical activity per week (e.g., 150 minutes of moderate-intensity activity) required to be (moderately) active [7]. This increases the risk of overweight, obesity and non-communicable diseases (NCDs) such as hypertension, stroke, diabetes, cardiovascular disease and certain types of cancer [4]. Specifically, overweight and obesity have been identified as two of the major health challenges facing more than one billion of the world's population. For example, in 2016, there were over 1.9 billion overweight adults (18 years and older) living in the world, with more than 650 million of them being obese and susceptible to NCDs. Moreover, in the same year, about 340 million children and adolescents aged 5-19 worldwide were overweight and obese [8]. Overweight and obesity are known as the fifth global risk factor of death, which account for 5% of the global mortality and affect countries across all income groups (high, middle and low) and across both genders (males and females) [3]. For example, in a lower-middle-income country such as Nigeria [9], the most populous nation on the African continent, NCDs accounted for 29% of all deaths in 2016 [10][11]. In the same year, in a high-income country such as the United States (US), the most populous nation on the North American continent, NCDs accounted for 88% of all deaths [12]. The same percentage of NCD-related deaths was recorded in Canada (a high-income country) in the same year [13].

The global incidence of physical inactivity and its attendant NCDs have created far-reaching financial and socio-economic implications at various levels of society, including individual, national and global [1]. In 2013, the global cost of physical inactivity (and its attendant NCDs) in direct healthcare was estimated to be US $54 billion per year, with an additional US $14 billion lost to unproductivity. In the United States, for example, the annual healthcare cost of physical inactivity is US $117 billion dollars [14]. In Canada, excluding costs associated with mental health and musculoskeletal conditions, physical inactivity accounts for 1–3% of healthcare costs [4]. The health, financial and socio-economic costs of physical inactivity call for urgent action in the health-related research communities, especially in the area of user study, design

[1] MET = Metabolic Equivalent of Task. MET is the ratio of a physical activity's metabolic rate to the resting metabolic rate [5][6]. MET-minutes represent the amount of energy expended carrying out physical activity for a given duration of time.

and implementation of data-driven health interventions that can reduce the incidence of physical inactivity [15]. According to the WHO [1], *"in the absence of evidence-based actions, the human, social and economic costs of NCDs will continue to grow and overwhelm the capacity of countries to address them"* (p. ix). Hence, it recommended that *"no country should be left behind, as the world steps decisively into the future to address one of the greatest public health challenges of the 21st century"* (p. ix). In response to this call, my dissertation sets out to research, investigate and evaluate potential effective ways grounded in theory, user-centered empirical evidence and technology (partly responsible for the problem) to tackle the physical-inactivity problem plaguing the world.

1.1 Research Problem

Physical inactivity has been identified as a global problem with far-reaching health and financial implications, which cut across culture, gender and age. Research [16] has shown that one of the most effective ways to improve well-being and cut down healthcare cost due to physical inactivity is to prevent its associated chronic diseases as early as possible by adopting an active lifestyle. However, meeting the WHO's physical-activity recommendation can be both challenging and difficult for most individuals due to a number of personal and social factors [17]. Apart from personal factors, such as lack of will power, motivation and self-efficacy, physical inactivity has been attributed to a number of socio-structural factors occasioned by modernity, industrialization, urbanization and technology [4]. For example, the technological advancements achieved in the last century (e.g., automobile, elevators, televisions, computers, etc.) have adversely affected active behaviors. As a result, people are more likely to undertake passive tasks (e.g., work with a computer, ride in automobile, play video games, etc.) than active tasks (e.g., work in the farm or factory, walk to a place, play outdoor games, etc.). Owing to these systemic challenges posed by modernity and technological advancement [4], there is a need for the adoption of a systematic approach in tackling the global problem of physical inactivity and its associated health challenges [18]. Specifically, there is a need to support individuals socio-technically at various levels of society in order to achieve the WHO's long-term goal of 15% reduction in physical inactivity between the year 2016 and the year 2030 [1][4].

Meanwhile, the global progress made by global institutions such as WHO *"to increase physical activity has been slow, largely due to lack of awareness and investment"* (p. 6) [4]. This calls for intensified efforts from the research community in an attempt to employ a systematic approach to address the global problem of physical inactivity, which is almost becoming a global epidemic [18]. According to WHO [4], *"failure to recognize and invest in physical activity as a priority within NCD prevention and treatment represents a missed opportunity"* (p. 16). Further, the world health body warns that *"ongoing inaction will see the costs of physical inactivity continue to rise, contributing to further negative impact on health systems, the environment, economic development, community well-being and quality of life for all"* (p. 16) [4]. These concerns and persistent calls for action by WHO and other well-meaning institutions prompted me to take on scientific research that attempts to uncover a systematic approach to address the global inactivity problem.

1.2 Motivation

Research has shown that, aside from good nutrition, regular exercise is *"critical to sustained good health"* [19]. However, regardless of culture, gender and race, physical activity levels tend to decline as people age [20]. As an attempt to address the physical inactivity problem, this dissertation aims to investigate the potential of persuasive technology (PT) as a motivational/supportive tool for promoting physical activity. PT is an interactive system that is intentionally designed to change human attitudes and behaviors in a positive way through the act of persuasion and social influence without deception or coercion [21]. Several studies [15][22] have shown its potential effectiveness in motivating behavior change in health domains such as physical activity, healthy eating, smoking cessation, etc. Given that many people find it difficult to exercise regularly due to lack of motivation, time, social support and access to gym [17][23], PT holds promise as a motivational tool for promoting physical activity. Hence, as an intervention measure, I intend to leverage PT as a motivational/supportive tool to encourage home-based bodyweight exercise. Home-based exercise (also known as calisthenics) requires no equipment, money or time to visit the gym that may be far away from home. In calisthenics, exercisers use their bodyweight as a resistance tool to work out different parts and muscles of their body by performing different exercises such as push-up, squat, plank, crunch, etc.

Given the various personal and socio-structural challenges associated with physical inactivity, the main focus of my dissertation is to investigate theory- and technology-driven interventions to promote an active lifestyle. Though there are existing free and commercial fitness applications on the market, most of them are neither informed by theory nor tailored to the user based on empirical evidence. This makes them to be less effective and difficult to evaluate in terms of what worked and what did not work for a given user or group [24]. However, research [25][26] has shown that theory-driven PTs, tailored to the target audience, are more likely to be effective than a one-size-fits-all PT. Hence, my dissertation aims to bridge the research gap by employing a multidisciplinary approach, grounded in theory and user models, to design, implement and evaluate a tailored PT intervention to promote regular exercise at home. The in-the-field evaluation of the intervention will enable me to specifically validate existing self-report-based PT design guidelines [27][28] in a real-life setting. Moreover, the validated PT design guidelines will help designers tailor their persuasive health applications (PHAs) to similar target users. Employing validated, evidence-based design guidelines to tailor PHAs to different cultural groups has the potential of improving physical activity, reducing the incidence of NCDs and the financial burden of healthcare cost associated with inactivity in the long run [15].

1.3 Research Objective

Most fitness applications on the market have been based on the one-size-fits-all approach, which has not been effective in bringing about the desired behavior change [29][30]. Research [26] has shown that, for persuasive applications to be more effective, there is a need for their personalization to the target users based on empirical evidence. However, most prior PT design guidelines, which are used to inform persuasive application design, have been based primarily on self-report data gathered *from* users (e.g., questionnaires, interviews, etc.) rather than experimental data gathered *on* users (with the aid of an actual application) [22]. Through self-reports, users are requested to provide information about their needs, attitudes and behaviors (e.g., [28], [31]) and subjective evaluation of mock-up applications/storyboards simulating real-life applications (e.g., [32], [33]). With the aid of these artifacts, user experience (UX) researchers in the field of Human-Computer Interaction (HCI) have been able to gather useful empirical data, upon which most PT design guidelines in the literature are based (e.g., [27], [31], [33]).

However, though less costly, easier to conduct, less time-consuming and supporting larger samples, self-reports may not be reliable due to lack of honesty, memory/recall bias, response bias, poor understanding and different interpretations of posed questions and rating scales by respondents [34][35][36]. For this reason, in recent years, there have been several calls for experimental studies in the field based on actual PHAs. Research shows that evidence-based design guidelines based on in-the-field PHA evaluations are more likely to be reliable for designing and implementing effective health interventions. However, there is limited work in this area of PT research, especially in the physical-activity domain. Thus, the ultimate objective of my dissertation is to provide an evidence-based solution to the research problem of physical inactivity by: (1) investigating a theory- and model-driven personalization method for tailoring PHAs to different target groups; (2) providing a framework for designing and evaluating theory-driven PHAs; and (3) providing in-the-field validated PT design guidelines for developing tailored PHAs to the different target groups.

Formally, the dissertation sets out to answer the following overarching research question (RQ0)[2]:

> *"Given the global problem of inactivity and unsuccessful attempts to tackle it in the past, how and to what extent could persuasive technology, especially when addressing cultural factors, be utilized to promote physical activity?"*

1.4 Research Approach

Research [37] shows that the full potential of PTs in achieving lasting behaviour change has not been attained yet. According to Henkemans et al. [37], this is as a result of lack of "*an effective combination of technical features and behavior change strategies*" in the design and implementation of behavior change interventions. Research [21][38] shows that a multidisciplinary approach that leverages insights and methods from different domains holds potential for optimizing the effectiveness of PT interventions. Hence, in an attempt to address the social problem of physical inactivity systematically, I proposed a multidisciplinary approach that cuts across three major domains of study as shown in Figure 1.1. They include Information Systems (Technology Adoption Model), Human-Computer Interaction (Persuasive Technology and Personalization) and Social Psychology (Behavior Change Theory). Basically, the approach leverages theories, models, principles and techniques from all three domains in proposing an evidence-based solution to the physical inactivity problem.

[2]The other research questions, which derive from the overarching, are presented in Section 1.5

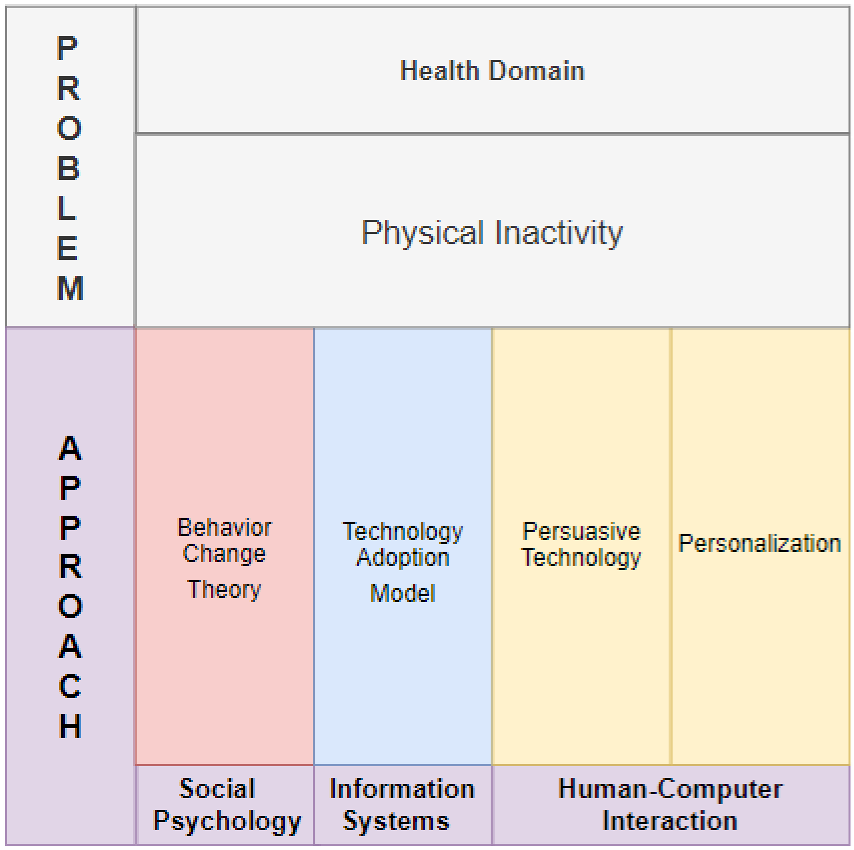

Figure 1.1: Multidisciplinary approach to tackling physical inactivity

1.4.1 Persuasive Technology

PTs are interactive systems that are intentionally designed to change human attitudes and behaviors through the act of persuasion and social influence without deception or coercion [21]. Basically, PT is the use of computers as a motivational medium or tool to change attitudes and behaviors. Fogg [39] proposed a framework, known as the Functional Triad, to explain how PT can be employed to change attitudes and behaviors. The Functional Triad illustrates three ways of using the computer as a persuasive system to change attitudes or behaviors: as a *tool*, *media* and *social actor*. As a tool, the computer is used to facilitate behavior change, e.g., a mobile health app that simplifies the performance of a given behavior through simulation. As a media, the computer is used to create and communicate a vicarious experience, e.g., a health app that simulates the cause-and-effect scenarios of a given health behavior. Finally, as a social actor, the computer plays the role of an expert (e.g., virtual coach, behavior model, etc.) that can positively influence the attitude and behavior of the target learner [39][40]. In my proposed solution to the physical inactivity problem, the implemented PHA plays all three roles. For example, it is equipped with videos of gender- and race-tailored behavior models that demonstrate to the user how a given type of bodyweight exercise (e.g., push-up, squat, etc.) can be correctly performed. As a tool, the PHA breaks down a target behavior into a sequence of steps to facilitate its performance. As a social actor and media, the PHA activates (highlights) the groups of muscles that are being impacted as the behavior model demonstrates the correct performance of a certain bodyweight exercise to the target user. Research [32] shows that PTs, such as behavior models, have the potential to positively influence users' social-cognitive beliefs, especially when tailored to the target users.

1.4.2 Personalization

Personalization, in the context of behavior change, is the act of tailoring PTs to the unique characteristics and preferences of the target users by the designer to increase their adoption and effectiveness in changing the target behavior. Most prior PT interventions have employed the one-size-fits-all approach, which has not been effective [29][30]. The moderating effect of key demographic factors, such as culture, have often been neglected in the design of such interventions. This limitation tends to affect their effectiveness in the field, hence, the need for personalization. Personalization can be implemented at different levels: *individual-based* and *group-based* [29]. While the individual-based method is more likely to be effective due to its catering to the individual's unique needs, preferences and motivational factors, the group-based method is easier and less costly to implement when demographic data is available. Due to limited research on group-based personalization (also known as tailoring) in the field, I chose to work in this research area.

Culture-Based Tailoring

Culture has been found to be one of the key demographic factors that define and/or distinguish groups of people. Hofstede [41] defines it as *"the collective programming of the mind which distinguishes the members of one group or category of people from another"* (p. 5). Moreover, Ford and Kotzé [42] define culture as *"the patterns of thinking, feeling and acting that influence the way in which people communicate among themselves and with computers"* (p. 714). In the HCI domain, studies [31][43] have shown that culture accounts for most of the variance of a population. Thus, it is important for HCI designers to tailor the design of applications to the target users' cultures to make them more effective [44][45]. For this reason, I set out, in this dissertation, to investigate how culture can be employed as a basis for understanding and fostering behavior change and PT acceptance.

Justification for Choosing Hofstede's Cultural Framework.

A number of frameworks has been proposed in the literature to explain culture. However, Hofstede's [41] and Hall's [46] frameworks are among the most commonly employed in cross-cultural research in general [47] and HCI research in particular [48][49]. Despite its shortcomings and criticisms (e.g., association of nation with culture) [49], Hofstede's [41] individualism vs. collectivism dimension of culture has been widely employed in most PT studies (e.g., [31], [50], [51]). Hence, in line with this practice, I based all of the user studies in this dissertation on the Hofstede's [41] individualism vs. collectivism dimension of culture.

Justification for Choosing Target Populations

Physical inactivity is a global problem which affects all people and countries, regardless of social, economic, technological and infrastructural development [3]. Hence, to understand how culture influences behavior change in two socially and culturally diverse populations, I chose Canada/United States (individualist culture) and Nigeria (collectivist culture). Canada/United States are developed/high-income countries, which are on one side of the socio-economic spectrum. On the other hand, Nigeria is a developing/lower-middle-income country [9]), which is on the other side of the socio-economic spectrum. Moreover, both types of culture, to a large extent, are plagued by NCDs and NCD-related mortality. For example, in 2016, NCDs accounted for 88% of all deaths in each of the two developed countries (Canada [13] and United States [12]), and 29% of all deaths in Nigeria [11]. For these reasons, I chose both disparate types of countries as a case study.

1.4.3 Technology Adoption Model

Technology, which has greatly contributed to the global decline of physical activity, is regarded as a double-edge sword, which can be employed for the good of humanity as well. Thus, given the ubiquity and affordability of technological devices such as smartphones in today's world, I intend to leverage technology as a means to tackle the inactivity problem that is almost becoming a pandemic [18]. Specifically, I aim to use PT to motivate users to exercise regularly in the comfort of their home without having to go the gym. However, people are not always willing to accept and/or use a new technology for a number of reasons. In some cases, they may be skeptical; in extreme cases, they may be completely resistant to adopting (*accepting* and *using*) it [52]. Technology adoption is regarded as a process which involves the user accepting the technology (after becoming aware of it) and making use of it (after accepting it) [53]. Thus, it is important for designers of PT interventions to understand the main inhibitors and drivers of the acceptance and use of a PHA [52]. Technology acceptance and use models help in anticipating the future needs of users in a complex and ever-evolving age of technologies and user requirements. In the adoption process, acceptance is a positive intention towards the new technology, which is a prerequisite to its use [53].

Technology Acceptance Model

In the research domain, a number of theoretical models, rooted in Social Psychology, have been put forward to explain the acceptance of a new information system [54]. One of the most popular models is the Technology Acceptance Model (TAM). It is used to explain users' acceptance of information systems in various domains such as health, business, education, etc. Over the years, the TAM has evolved into many variants such as TAM 2 [55], Unified Theory of Acceptance and Use of Technology (UTAUT) [56], etc. However, for the purpose of this dissertation, I focus on the traditional TAM [57], as revised and extended by a number of researchers such as Van der Heijden [58], which is relevant to my proposed PT intervention. The TAM is a theoretical model which comprises a number of important UX design attributes for explaining the acceptance of a new information system by potential users. Research [58][59] has shown that UX design attributes such as *perceived usefulness*, *perceived ease of use*, *perceived credibility* and *perceived aesthetics* are among the important determinants of the acceptance of an information system. In this dissertation, among my target audience, I aim to uncover the strongest and most important UX design attributes that determine the acceptance of a proposed PHA by each type of culture using the extended TAM [58], which I called Persuasive Technology Acceptance Model (PTAM).

Technology Use Model

In the adoption process, Technology Use Model (TUM) can be defined as those features of an information system (other than UX design attributes) that explain its use. In the context of PT, I refer to such a model as a Persuasive Technology Use Model (PTUM). Hence, in this dissertation, PTUM is defined as the persuasive (design) features that explain the use of a PHA in motivating behavior change. Basically, persuasive features are the motivational features (affordances) of a PHA that have the capacity to positively influence behavior change. In general, apart from the perceived UX design attributes (which account for the acceptance of a PHA), users' motivation towards the uptake (i.e., use) of a new technology (e.g., an information system) is based on a number of utility-based expectations from the technology. Those expectations include the technology being productive or instrumental to helping its users accomplish their tasks [60]. In the UX-design-based evaluation of a persuasive system, users' utility-based expectations are usually encapsulated in the instrumental construct known as *perceived usefulness*, which operationalizes the functionality of the system. In the case of PTs, research [15][61][62] shows that persuasive features such as Goal-Setting, Self-Monitoring, Reward, Cooperation, etc., are instrumental to the use of a PHA to motivate behavior change. Particularly, they motivate and facilitate user engagement and performance of the target behavior such as physical activity. In this dissertation, in the context of PTUM, I hope to uncover the strongest and most important persuasive features that determine the use of a PHA after users have accepted it.

1.4.4 Behavior Change Theory

Research [63] has shown that theory- and model-driven PTs are more likely to be successful. Behavior (change) theories are models of interrelated constructs that explain the underlying factors responsible for behavior change [64]. Such factors include personal, social and environmental. According to Glanz [65], behavior theories can help interventions in three ways:

1. Understand *why* people do or do not engage in healthy behaviors;

2. Identify *what* information is required to design an effective intervention; and

3. Provide insight into *how* to design and implement a successful intervention.

Understanding why people do or do not engage in healthy behaviors

Research [63] has shown that the most successful health interventions are based on understanding the behavioral determinants of the target audience and the context in which they occur. Commonly used behavior theories in health interventions include Social Cognitive Theory (SCT), Theory of Reasoned Action/Theory of Planned Behavior, Self-Determination Theory, Social Ecological Model, Transtheoretical Model, Health Belief Model, etc. [22][64]. In this dissertation, I chose to use the SCT to inform the PT intervention. The SCT is an explanatory theoretical model, which conceptualizes behavior change as a causal model of reciprocal determinism [65]. Particularly, it holds that human behavior is influenced by both cognitive (personal) factors and environmental factors, both of which influence each other. The main cognitive factors (constructs) studied extensively in the social-cognitive model include Self-Efficacy, Self-Regulation and Outcome Expectation, while the main environmental factors studied widely include Social Support. Other environmental social-cognitive factors less studied include Physical Environment, Technology, etc. All of these social-cognitive constructs are possible determinants (drivers) of physical activity [66].

Identifying what information is required to design an effective intervention

To design an effective intervention, there is a need to operationalize the determinants of behavior in the application domain. Specifically, once the theoretical determinants of the target behavior for a given target group are found through user studies and path modeling, they are mapped to the corresponding implementable persuasive strategies in the application domain.

Providing insight into how to design and implement a successful intervention

The model serves as a basis for the determination (selection) of possible strategies (mapped to behavioral determinants) to be implemented in the intervention. In the case of PT interventions, the selection of strategies to be implemented in a persuasive application can be achieved in further user studies in the application domain. For example, to investigate the receptiveness of the target group to certain persuasive strategies in the application domain, a user study that employs storyboards to illustrate the persuasive strategies, is carried out. Then the persuasive strategies to which the target group is most receptive are implemented in the persuasive application aimed to motivate behavior change in the field.

1.5 Research Questions

Research [22][63] shows that PTs are more likely to be effective if they are informed by theory, empirical evidence and tailored to the target users. However, there are limited studies on how behavior theories and culture can be employed to tailor PHAs in the physical-activity domain. Thus, in this dissertation, I set out to answer seven research questions derived from the overarching research question presented in Section 1.3, using Nigeria (a collectivist culture) and Canada/United States (an individualist culture) as a case study.

RQ1. How can behavior change theory be employed to inform a PT intervention to promote physical activity?

(a) What are the theoretical determinants of the physical-activity behavior of the two target cultures?

(b) How can the theoretical determinants be operationalized in the application (technology) domain?

(c) What are the performance levels of the theoretical determinants in the two target cultures?

The research question will help in understanding the theoretical determinants of physical activity and their performance levels and the moderating effect of culture. The second subquestion will help in the mapping of the culture-specific theoretical determinants to persuasive strategies in the application domain. Finally, the third subquestion will help in uncovering the culture-specific perceived levels of the theoretical determinants.

RQ2. What are the persuasion profiles of the target audience in the application domain and how are they moderated by culture?

(a) How do the two types of culture differ in their receptiveness to commonly employed *personal* persuasive strategies/features in the application domain?

(b) How do the two types of culture differ in their receptiveness to commonly employed *social* persuasive strategies/features in the application domain?

This research question will help in determining the receptiveness of the target audience to commonly employed persuasive strategies/features (personal and social) in the application domain, to which the theoretical determinants of physical-activity behavior have been mapped. Moreover, it will help (using a mixed-method approach) in understanding how the culture-specific theoretical determinants of physical activity compare with the culture-specific persuasion profiles in the application domain and how both cultures differ.

RQ3. What methods and/or models can we use to understand the adoption of a new technology-based intervention by the target audience?

(a) Using the PTAM, which of the common UX design attributes are the strongest determinants of the acceptance of a PHA and how are they moderated by culture?

(b) What are the prominent UX design attributes of a PHA that grab users' attention and how are they moderated by culture?

(c) Using the PTUM, which of the common persuasive design features are the strongest determinants of the use of a PHA and how are they moderated by culture?

(d) What are the key features of a PHA users care about and how are they moderated by culture?

The first two subquestions are concerned with technology *acceptance*, while the last two subquestions with technology *use*. Particularly, the first subquestion, in the context of the extended TAM, helps to uncover the strongest UX design attributes that determine the acceptance of a PHA (prototype) using a quantitative approach. The second subquestion repeats the quantitative study that addresses the first subquestion using a qualitative approach. It aims to understand the UX design attributes that stand out when the target users first come in contact with a PHA. Moreover, the third subquestion helps, in the context of PTUM, to uncover the most important persuasive design features that determine the use of a PHA using a quantitative approach. Finally, the fourth subquestion employs a qualitative approach to uncover the key application features (supportive and persuasive) that make the target audience want to use a PHA to motivate their physical activity. Unlike persuasive features (e.g., Goal-Setting, Reward, etc.), supportive features are application utilities that may not be persuasive but helpful in encouraging behavior change, e.g., Exercise Timer.

RQ4. How can we leverage the culture-specific empirical findings from the user studies in the design of an actual PHA tailored to the target audience?

This research question will help in operationalizing all of the empirical findings in the application domain. Specifically, based on all of the empirical findings in the user studies (physical-activity modeling, persuasion profiling, UX-design-attribute and application-feature requirements), a culture-tailored PHA will be designed and implemented for the two cultural groups to motivate their physical-activity behavior change in the field.

RQ5. How can we evaluate the UX design of an actual PHA prior to its usage in the field?

(a) Does the UX design determinants of the *intention to use* a PHA (prototype) generalize to an actual application (evaluated in the field)?

(b) Does the actual PHA meet the UX design requirements for its acceptance by the target audience?

The first subquestion will help in determining whether the PTAM (based on a PHA prototype) for the two types of culture can be replicated based on an actual PHA piloted in the field. Moreover, the second subquestion will help in determining whether the UX design of the actual PHA meets users' requirements and expectations in terms of the UX design attributes that they consider important in the adoption of a PT.

RQ6. How can we evaluate the effectiveness of an actual PHA in changing behavior in the field?

(a) Is the actual health application equipped with persuasive features more likely to be effective in motivating the physical-activity behavior of the target audience than the unequipped?

(b) Is the tailored PHA more likely to be effective in motivating the physical-activity behavior of the target audience than the untailored?

Both subquestions will help in investigating the overall and culture-based tailoring effectiveness of the PHA, respectively, among the target audience in a field setting.

RQ7. Do the social-cognitive determinants of physical-activity behavior in the theory domain (based on self-report) generalize to the application domain?

This research question will help in determining the replicability of my initial empirical findings regarding the social-cognitive determinants of physical-activity behavior (based on self-report) in an experimental setting (in the field). This will allow for the refinement of my initial self-report-based PT design guidelines [27] based on new experimental evidence emerging from the field.

1.6 Research Methodology

To answer the overarching research question presented in Section 1.3 using the multidisciplinary approach presented in Section 1.4, I adopted the Design Science Research Methodology (DSRM) for information systems design. The DSRM is "*a commonly accepted framework for successfully carrying out DS research*" (p. 48) [67]. The DSRM (which I adapted) is composed of five stages: (1) identification and definition of problem and solution; (2) user study and modeling; (3) design, implementation and demonstration of a persuasive health intervention; (4) evaluation of the effectiveness of the proposed persuasive health intervention; and (5) communication of findings.

1.6.1 Research Design

Research design is the blueprint employed by researchers for data collection and analysis. It helps researchers to gather empirical and experimental evidence that enables them to effectively address the research problem at hand. The evidence gathered on the research problem is employed to build models, test a theory or evaluate an intervention [68]. To answer the dissertation's research questions and test its hypotheses, I employed empirical studies (based on self-reports) and an experimental study (based on the actual use of a PHA) using a mixed-method approach. In the empirical studies, I requested the study participants to respond to both quantitative and qualitative questions. The quantitative questions were closed-ended. They measured empirical constructs (e.g., *perceived aesthetics*) on a Likert scale. On the other hand, the qualitative questions were open-ended. They required the study participants to provide comments and feedback on the user interface (UI) design of a PHA prototype or a persuasive feature (e.g., Reward) illustrated on a storyboard. The mixed method allows researchers to uncover useful insights into a single investigation from different perspectives. This allows the researchers to triangulate (cross-verify) the qualitative findings with the quantitative findings to increase the reliability of the overall findings [69]. Finally, in the experimental study, I requested the study participants to use an actual PHA in the field for four weeks and tracked their physical activity including their step count and bodyweight exercise.

1.6.2 Data Collection

To collect the required data for the dissertation, I used paper-based means and three different online data-collection tools to recruit participants of different demographics. The online tools include Google Forms, Survey Monkey and Fluid Survey. Google Forms is free, while the other two, which are now owned by Survey Monkey are commercial. To recruit online participants, I employed Amazon Mechanical Turk (MTurk) [70], social media (Facebook and LinkedIn), email and University of Saskatchewan's announcement portal. MTurk is an online data-collection platform used for recruiting anonymous research participants from different parts of the world. One of its advantages is that "*the data obtained are at least as reliable as those obtained via traditional methods*" (p. 3) [70]. In appreciation of participants' time, the platform is integrated with a compensation system, which allows researchers to compensate their participants with a token amount upon completion of tasks. In my studies, the compensation of participants ranged from US $0.5 to US $1.50. Prior to taking the surveys, participants were requested to consent. The consent forms for all of the studies, approved by the University of Saskatchewan Research Ethics Board, are provided in Appendices A-G.

1.6.3 Data Analysis

I adopted a mixed method (quantitative and qualitative) in the analysis of gathered data from the user studies. I employed both methods to enable triangulation of different findings. Triangulation is defined as the act of combining more than one research method to study one problem [71]. Regarding the quantitative data, I employed Partial Least Square Path Modeling (PLSPM), a soft variant of Structural Equation Modeling (SEM) [72], and Analysis of Variance (ANOVA). SEM is a multivariate statistical analysis technique that allows researchers to investigate the interrelationships that exist among a number of constructs which fall into two categories: *exogenous* and *endogenous*. The relationship between two constructs starts from the exogenous construct and terminates in the endogenous construct. Although, path models are recursive (i.e., unidirectional), they are based on correlations. As a result, the one-way relationship between two given constructs in the path models in this dissertation does not imply causation. Similarly, the use of the word "determinant" in the dissertation does not imply causation either. Overall, SEM shows how well a number of exogenous constructs collectively explain a certain endogenous construct known as the target construct (e.g., Physical Activity) [73]. Specifically, I used the "plspm" package in R Studio environment [74] to conduct PLSPM in this dissertation. Moreover, I computed and plotted the average ratings of the empirical constructs of interest (e.g., Perceived Self-Efficacy) by a group of participants to determine the constructs' performance profile for the group. Then, using the ARTool package in R [75][76], I employed a non-parametric ANOVA to uncover how the two cultural groups of interest (collectivist and individualist) significantly differ ($p < 0.05$) in the average rating of each construct. Finally, regarding the qualitative data, I employed a thematic analysis [77] to tease out recurring themes in the data and how they differ between the two cultures. Overall, the qualitative data analysis helps in confirming and explaining the quantitative findings through triangulation.

1.7 Research Solution

Research [63][22] shows that PHAs are more likely to be effective if they are theory-driven and tailored to the target audience. Yet, most existing PHAs on the market are neither theory-driven nor tailored to the target audience. They are often designed based on a one-size-fits-all approach. As a result, the rationale for their design and adoption are unknown, making it difficult to understand what design decisions and/or persuasive features were effective or ineffective. According to Campbell et al. [78], *"[p]roblems often arise in the evaluation of complex interventions because researchers have not fully defined and developed the intervention"* (p. 694). Specifically, very little attention has been paid to the design process, in particular, to that which is amenable to the tailoring of PTs to different target users and the evaluation of what theory-driven persuasive strategies worked and did not work in the application domain.

According to Michie et al. [63], *"[t]heory provides a helpful basis for designing interventions to change behaviour but offers little guidance on how to do this."* (p. 660). To bridge this gap, I proposed a data-gathering and application-design framework, called "EMVE-DeCK (Explain-Map-Validate-Explain-Design-Change-Knowledge) Framework," for analyzing, understanding and synthesizing all of the user studies I carried out in the second and fourth stages of the DSRM. This framework is pertinent given that it lays down a design process which spans the theory domain of Social Psychology and the application domain of PT. Hence, it (or parts of it) can be leveraged by future theory-oriented designers who want to employ Social Psychology theories (e.g., SCT, Health Belief Model, Self-Determination Theory, etc.) and empirical evidence in a systematic fashion to design and evaluate the effectiveness of PTs tailored to their target audience.

In a nutshell, the framework demonstrates how a designer can employ theory in terms of behavior determinants and persuasive affordances of technology in explaining and designing PTs for motivating behavior change, respectively. According to Michie et al. [63], there are three main reasons for the call for the use of theory in designing and evaluating interventions. They include: (1) interventions are more likely to be effective if the causal determinants of behavior are targeted; (2) theory can only be tested and developed further through the evaluations of interventions in experimental settings if the interventions and evaluations, in the first place, are theoretically informed; and (3) theory-based interventions foster an understanding of what worked and did not work, which provides a basis for the refinement and improvement of theory across different populations and contexts.

Moreover, Michie et al. [63] stated that theory summarizes the hypothesized causal processes that are involved in behavior change. According to the authors, theory-based interventions, unlike "theory-inspired" interventions, "*use an explicit causal pathway [...] and enable the intervention developer to avoid implicit causal assumptions which may lack evidence or even have been invalidated*" (p. 662) [63]. Further, they argued, "*[e]ven when people use theory, they tend to use it to explain behaviour but not to change behaviour*" (p. 663) [63]. However, the EMVE-DeCK Framework does not only support the explanation of behavior but provides a technology-based design process to motivate and evaluate behavior change in the field.

1.7.1 The EMVE-DeCK Framework: Steps to Proposed Solution

The EMVE-DeCK Framework provides a seven-step process model, grounded in Bandura's [79] Triad of Reciprocal Determinism, for designing and implementing PT interventions. Basically, the framework, which integrated theory and PT design steps from the Michie et al. [63] framework and Oinas-Kukkonen and Harjumaa's [61] Persuasive System Design (PSD) framework, respectively, is aimed at changing "Behavior" using "Theory" and "Technology." The seven steps in the framework include: (1) Explain: Employ "Theory" to *explain* the performance of the target "Behavior" by uncovering the relationship between the "Behavioral Determinants" and the target "Behavior"; (2) Map: *Map* the significant "Behavioral Determinants" in the "Theory" domain to "Persuasive Strategies" in the "Technology" domain; (3) Validate: *Validate* the target users' receptiveness to the "Persuasive Strategies" in the "Technology" domain; (4) Explain: Employ "Theory" to *explain* the adoption of the proposed persuasive "Technology" by uncovering the relationship between the UX/persuasive "Design Determinants" and the proposed "Technology Adoption"; (5) Design: *Design* and implement theory-driven, tailored persuasive "Technology"; (6) Change: Deploy "Technology" to *change* "Behavior" in the field; and (7) Knowledge: Contribute "Findings" to *Knowledge*. As a proof of concept, I employed the framework as a basis for conducting all of the user studies in this dissertation.

1.7.2 Mapping of the EMVE-DeCK Framework to Research Questions

Using the EMVE-DeCK Framework , I conducted a number of user studies to provide answers to the seven research questions of this dissertation laid out in Section 1.5. Table 1.1 shows a mapping of all of the user studies (carried out and presented in this dissertation) to the seven main research questions. Moreover, the research questions, in turn, are mapped to the different stages of the DSRM and steps of the EMVE-DeCK Framework. The first study (S0: mapped to the overarching research question of this dissertation (RQ0) and the first stage of the DSRM) that I carried out is a literature review of the physical inactivity problem and the potential of using information technology to address it. This study constitutes my comprehensive report which I defended before my committee members prior to coming up with a research proposal for the dissertation. The second study (S1: mapped to RQ1) I carried out is the investigation of the target audience's theoretical determinants of physical-activity behavior and the moderating effect of culture. In the context of the EMVE-DeCK Framework, I employed the SCT to explain the physical-activity behavior of the two types of cultures (Explain) and mapped the significant determinants to persuasive strategies in the application domain (Map). The third study (S2: mapped to RQ2) I carried out is the investigation of the target audience's persuasion profile in the application domain and the moderating effect of culture. In this study, I investigated the persuasive strategies to which the two types of cultures are receptive. This study is aimed at validating in the application domain both target groups' receptiveness to the persuasive strategies, to which the behavioral determinants in the theory domain were mapped (Validate). The fourth study (S3: mapped to RQ3) is the investigation of the target audience's PTAM and the moderating effect of culture.

Table 1.1: Mapping of the EMVE-DeCK Framework to user studies, DSRM and research questions. LR = Literature Review, QUANT = Quantitative, E = Explain, M = Map, V = Validate, De = Design, C = Change, K = Knowledge. In total, four datasets were gathered: S1 is based on the first dataset; S2 and S3 on the second dataset, S4 on the third dataset, and S5 on the fourth dataset.

RQ	DSRM Stage	Method	Study	Study Title	Step
RQ0	Stage 1: Identification and definition of problem and solution	LR	S0	Investigation of physical inactivity problem, theories of behavior change and technology-driven interventions	-
RQ1		QUANT	S1	Investigation of the target audience's theoretical determinants of physical-activity behavior and the moderating effect of culture	E & M
RQ2	Stage 2: User study and modeling	MIXED	S2	Investigation of the target audience's persuasion profile in the application domain and the moderating effect of culture	V
RQ3		MIXED	S3	Investigation of the target audience's persuasive technology adoption models and the moderating effect of culture	E
RQ4	Stage 3: Design, implementation and demonstration of proposed PT health intervention	MIXED	-	Design and implementation of culture-tailored persuasive health application based on empirical findings from S1-S3	De
RQ5		QUANT	S4	Pre-Evaluation of the UX design of actual persuasive health application prior to usage in the field	
RQ6	Stage 4: Evaluation of PT health intervention	MIXED	S5	Evaluation of the overall and culture-tailoring effectiveness of actual persuasive health application in the field	C
RQ7		-	-	Validation and refinement of initial culture-specific findings (based on self-reports) in the field (based on experimental evidence)	
RQ1-RQ7	Stage 5: Communication of findings	WRITING	S1-S5	Publication of research findings in journals, conferences and dissertation	K

In this study, I investigated the UX/persuasive design factors that determine (i.e., explain) the acceptance of a PHA and the key application features (supportive and persuasive) the two types of culture care about (Explain). In the fifth step of the EMVE-DeCK Framework, I designed and implemented the proposed PHA based on the empirical findings in the first four steps of the framework (Design). After the design and implementation of the PHA, in the fifth study (S4: mapped to RQ5), I pre-evaluated the UX design of the PHA to determine its meeting the target users' requirements. Thereafter, in the sixth study (S5: mapped to RQ6), I evaluated the overall and culture-tailoring effectiveness of the PHA in the field (Change). Then, based on the emergent findings from the pilot study in the field (i.e., experimental evidence), I validated the previous findings (based on self-reports) from the previous steps of the EMVE-DeCK Framework. Finally, the findings from the user studies are published in academic journals, conferences and workshops.

1.7.3 Design of Culture-Tailored Persuasive Health Application

Using the EMVE-DeCK Framework, I designed and implemented a culture-tailored PHA called BEN'FIT based on empirical evidence gathered from the first four steps of the framework. BEN'FIT is a fitness app aimed at motivating bodyweight exercise at home. It comprises two versions: personal version (PV) and social version (SV). The PV version is tailored to users in the individualist culture. It is equipped with individual-based Goal-Setting, Self-Monitoring and Reward persuasive features. These personal features were found in the first three steps of the EMVE-DeCK Framework to be the strongest drivers of behavior change in the individualist culture. The SV version is tailored to users in the collectivist culture. It is equipped with collaborative features such as group-based Goal-Setting, Self-Monitoring, Reward, Cooperation, Social Learning and Social Comparison. These social features were found in the first three steps of the EMVE-DeCK Framework to be the strongest drivers of behavior change in the collectivist culture. Finally, I developed a control version (CV) called EXLOGGER, against which the PV and SV versions were compared in terms of effectiveness. The EXLOGGER app is basically an electronic journal for logging and tracking users' exercises. Based on the findings from the preliminary user studies, I hypothesized that the PV and SV versions will be more effective than the CV version in changing behavior. Moreover, I hypothesized that the PV and SV versions will be more effective in changing behavior in the individualist and collectivist cultures, respectively.

1.7.4 Development Tools and Evaluation of Persuasive Health Application

A number of software tools were employed in the development of the PHA. The BEN'FIT and EXLOGGER apps were developed using the Android Studio [80]: an open-source integrated development environment (IDE) provided by Google for the development of mobile applications. Second, GitHub was used as a collaborative online repository for the version control, review and management of the app source code [81]. Third, Google Firebase was employed to provide cloud-based services (such as Authentication, Database, Cloud Messaging, Data Storage, Notifications, etc.) to the apps [82]. Fourth, Google Fit Application Programming Interfaces (APIs) were used as a service to automatically track users' daily step counts [83]. Fifth, Google Play Store was used to host the app. Finally, Google Console Play [84] was used to invite preselected participants from both cultures to download the app from the Play Store and pilot it for a four-week period.

1.8 Main Research Findings

The main research findings are theory and technology (application) based. In the theory domain, using the SCT as a behavior-modeling framework, I found that Self-Efficacy and Self-Regulation are the strongest determinants of physical-activity behavior in the individualist culture. These theoretical determinants were mapped to individual-based persuasive strategies such as Goal-Setting, Self-Monitoring and Reward in the application domain. In contrast, I found that Social Support is the strongest determinant of physical-activity behavior in the collectivist culture. This theoretical determinant was mapped to group-based persuasive strategies such as Cooperation, Social Learning and Social Comparison in the application domain.

Secondly, in the application domain, I found that members of the collectivist culture are likely to be receptive to social strategies such as Cooperation, Social Learning and Social Comparison (as well as personal strategies such as Goal-Setting/Self-Monitoring and Reward implemented in a social setting). In contrast, I found that members of the individualist culture are more likely to be receptive to personal strategies such as Goal-Setting/Self-Monitoring and Reward and less likely to be receptive to social strategies. Both culture-specific findings validate the SCT-based findings that personal and social factors are the strongest determinants of physical activity in the individualist and collectivist cultures, respectively.

Thirdly, in the application domain, in a PHA-prototype and actual-PHA based studies, I found that, regardless of culture, *perceived usefulness* and *perceived aesthetics* are the strongest UX design determinants of the acceptance of a PHA. The finding suggests that users care about the visual aesthetics of a PHA as much as they care about its functionality. Most importantly, it calls on PT designers to strike a balance between *beauty* and *utility* in the design of PHAs aimed at motivating behavior change.

Finally, based on different metrics, I uncovered a number of findings in a four-week pilot of the three versions of the PHA in the field: (1) the PV and SV versions are more effective than the CV version; (2) the PV version is more effective than the SV version for the individualist culture; (3) the SV version is more effective than the PV version for the collectivist culture; (4) the PV version is more effective for the individualist culture than for the collectivist culture; (5) the SV version is more effective for the collectivist culture than for the individualist culture; (6) collectivist users are more likely to engage in walking than individualist users; and (7) regardless of culture, users are more likely to engage in walking than in exercise.

1.9 Main Research Contributions

As my contribution, I demonstrated how theory and culture could be successfully employed to tailor PHAs. First, I showed the culture-specific SCT determinants of physical activity and validated them in the application domain. Second, based on my findings in the theory and application domains, I provided a set of PT design guidelines for developing PHAs for both cultures. Third, in the context of UX design, I showed that, regardless of culture, hedonic (*perceived aesthetics*) and utilitarian (*perceived usefulness*) factors influence the acceptance of a PHA. Further, I showed that *perceived persuasiveness* mediates PT acceptance for the individualist culture, but does not for the collectivist culture. Finally, I showed that, in the context of PT design, regardless of culture, Goal-Setting/Self-Monitoring is the strongest predictor of the use of a PHA.

1.10 Organization of Dissertation

This dissertation is organized into ten chapters. For transparency, in terms of how the studies are related and each of them follows from the previous, I present the organization of the rest of the chapters as shown in Table 1.2. Chapter 2 focuses on the Research Background. Chapter 3 focuses on the Research Methodology. Chapters 4, 5 and 6 focus on the user studies (mapped onto the subquestions of the first three research questions) that informed the design and implementation of the culture-tailored PHA (Chapter 7). Chapters 8 and 9 focus on the pre-evaluation and evaluation of the implemented PHA in the field, respectively. Finally, Chapter 10 concludes the dissertation by summarizing its findings, contributions, limitations and future work.

Table 1.2: Outline of the chapters, research questions and user studies presented in the dissertation. RQ = Research Question, LR = Literature Review, UX = User Experience, PHA = Persuasive Health Application, EMVE-DeCK = Explain-Map-Validate-Explain-Design-Change-Knowledge. In total, four datasets were gathered: S1a and S1b is based on the first dataset, S2a-S2c and S3a-S3d on the second dataset, S4a and S4b on the third dataset, and S5 on the fourth dataset.

Chapter	Title of Study	RQ	Study	Description of Chapter / Title of Study
Chapter 2	Research Background	RQ0	LR	Social Cognitive Theory, Technology Adoption Model, Persuasive Technology and Personalization, Mapping of Technology Acceptance Model to Captology ("Computers As Persuasive Technologies"), Non-Theory- and Theory-Driven Persuasive Design Frameworks, their limitations, Types of Behavior Change, and Gaps in the Existing PT Literature
Chapter 3	Research Methodology	-	-	DSR Methodology, EMVE-DeCK Framework, Data Collection and Analysis, and Research Design
Chapter 4	Theoretical Determinants of Behavior	RQ1	S1a	Investigation of target audience's social-cognitive determinants of physical-activity behavior and the moderating effect of culture: a quantitative approach
			S1b	Investigation of the social-cognitive-beliefs profile of the target audience and the moderating effect of culture: a quantitative approach
Chapter 5	Users' Receptiveness to Persuasive Features in Application Domain	RQ2	S2a	Investigation of the persuasion profile of the target audience and the moderating effect of culture: a quantitative approach
			S2b	Investigation of the drivers of the receptiveness of the target audience to the personal persuasive features in the application domain and the moderating effect of culture: a qualitative approach
			S2c	Investigation of the drivers of the receptiveness of the target audience to the social persuasive features in the application domain and the moderating effect of culture: a qualitative approach
Chapter 6	Persuasive Technology Adoption Model	RQ3	S3a	Investigation of the UX design determinants of the acceptance of a PHA (prototype) among the target audience and the moderating effect of culture: a quantitative approach
			S3b	Investigation of the UX design determinants of the acceptance of a PHA (prototype) among the target audience and the moderating effect of culture: a qualitative approach
			S3c	Investigation of the persuasive design determinants of the use of a PHA (prototype) among the target audience and the moderating effect of culture: a quantitative approach
			S3d	Investigation of the key application features that make the target audience want to use a PHA and the moderating effect of culture: a qualitative approach
Chapter 7	Design and Implementation of Culture-Tailored Persuasive Health Application	RQ4	-	Design and implementation of an actual culture-tailored PHA (BEN'FIT) based on empirical findings from S1-S3
Chapter 8	Pre-Evaluation of Culture-Tailored Persuasive Health Application Prior to Usage in the Field	RQ5	S4a	BEN'FIT: Investigation of the UX design determinants of the acceptance of an actual PHA among the target audience and the moderating effect of culture
			S4b	BEN'FIT: Investigation of the perception profile of the target audience regarding the perceived UX design attributes of an actual PHA and the moderating effect of culture
Chapter 9	Evaluation of Culture-Tailored Persuasive Health Application in the Field	RQ6	S5	BEN'FIT: Evaluation of the overall and culture-tailoring effectiveness of an actual PHA in the field
		RQ7	-	Validation and refinement of initial culture-specific PT design guidelines (based on self-reports on social-cognitive determinants of physical-activity behavior) in the field (based on the evaluation of the actual PHA)
Chapter 10	Conclusion	-	-	Summary of Findings, Contributions, Limitations and Future Work

2 Research Background

This chapter provides a background on the four main aspects of the multidisciplinary solution framework shown in Figure 1.1. Specifically, it provides an overview of the Social Cognitive Theory (SCT), Technology Adoption Model, Persuasive Technology (PT) and Personalization. Moreover, it focuses on the relationship between Technology Acceptance Model (TAM) and Captology ("Computers As Persuasive Technologies"), Non-Theory- and Theory-Driven Persuasive Design Frameworks, and their limitations. It concludes by discussing the types of behavior change and the gaps in the prior PT literature on health behavior change.

2.1 Social Cognitive Theory

The SCT is an established behavior change theory that has been widely used for health promotion and intervention design [36][66]. Its popularity is partly due to its focus on the individual as well as the environment as determinants of behavior [85]. Other behavior change theories such as the original Health Belief Model do not recognize the environment as a behavioral determinant. The SCT was put forward by Bandura [86] to explain human behaviors. It holds that human behaviors are determined by both cognitive as well as environmental factors. Based on the Social Learning Theory [87], the SCT posits that people learn not only through their own experiences, but also by observing the behaviors of others and their consequences [64][88]. The SCT is encapsulated in the conceptual Triad of Reciprocal Determinism (TRD) [79]. The TRD (Figure 2.1) holds that three main factors (*personal*, *environmental* and the *target behavior* itself) reciprocally influence one another in a dynamic fashion to shape human behaviors [89]. Figure 2.2 shows an instantiation of the TRD in the physical-activity context. The model depicts the interrelationships among six constructs representing the three main factors in the TRD. The personal factors include cognitive constructs such as Self-Efficacy, Outcome Expectation and Self-Regulation, while the environmental factors include Physical Environment, Social Support and Technology. All of these factors can act as impediments (demotivators) or facilitators (motivators) of behavior change, which can have direct or indirect influence on the target behavior.

Aside from being one of the most commonly used behavior change theories in health interventions [90], I chose to use the SCT for two main reasons. The first reason is that it explains almost one-third of the variance of Physical Activity, *"which meets Baranowski et al.'s* [91] *recommendation for a theory to be considered a useful framework for intervention design*" (p. 15) [92]. The second reason is that it maps very well to Oinas-Kukkonen and Harjumma's [61] Persuasive Design System (PSD) model. For example, the personal factors in the SCT model (e.g., Self-Efficacy and Self-Regulation) map to the Primary Task and Dialog Support categories, while the environmental factors (e.g., Social Support) map to the Social Support category.

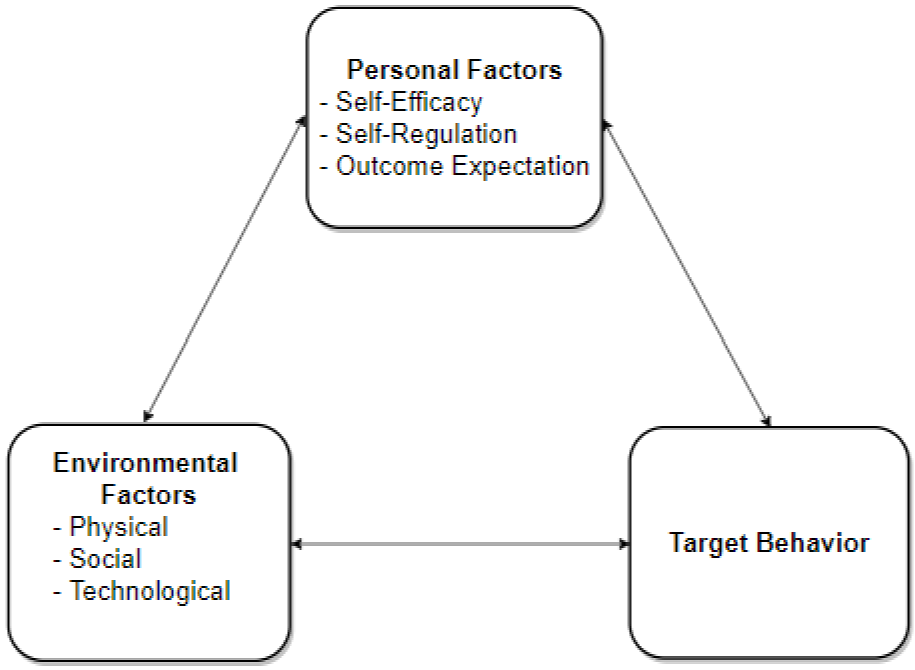

Figure 2.1: SCT framework depicting the triad of reciprocal determinism (adapted from[79])

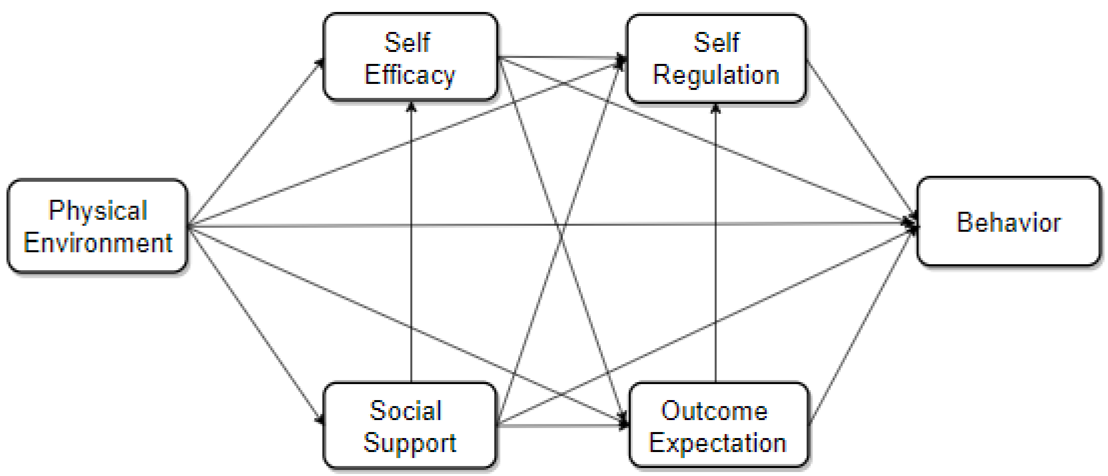

Figure 2.2: Instantiation of the triad of reciprocal determinism (aka social-cognitive model) [27]

Self-Efficacy. Self-Efficacy is the belief in one's ability to perform a certain behavior [93]. It has been found to be the strongest and most consistent determinant of behavior [93][94]. It influences behavior proximally (directly) and distally (indirectly). For example, in Figure 2.2, it directly influences Outcome Expectation and Self-Regulation. However, it directly and indirectly influences the target behavior via both constructs.

Self-Regulation. Self-Regulation refers to the management and control of one's thoughts, feelings, motivations and actions towards the achievement of one's goals. It involves goal-setting, self-monitoring, self-evaluation, organization, planning and control of ones' behavior. According to Bandura [95], human behaviors are motivated and regulated extensively by the exercise of self-influence. He stated that the major self-regulatory mechanism in human behaviors operates through three primary subfunctions: (1) monitoring of one's behavior, its determinants and effects; (2) judgment of one's behavior relative to personal standards and environmental circumstances; and (3) affective self-reaction. He argued that humans possess some level of self-reflective and self-reactive capabilities, which enable them to exercise control over their thoughts, feelings and actions. Otherwise, he submitted, if humans were influenced by external factors alone, they would behave like weathervanes that constantly shift directions to conform to the prevailing social influences [95].

Outcome Expectation. Outcome Expectation is a person's judgment of the possible consequences (positive or negative) of engaging in a certain behavior. The outcome expectations about the consequences or effects of certain behaviors influence their performance and non-performance, including making such behaviors a habit or lifestyle. Bandura [66] identified three types of Outcome Expectation: physical, social and self-evaluative. Physical Outcomes entail pleasant sensory experience (e.g., physical pleasure, better physique, etc.) and aversive sensory experience (e.g., pain, discomfort, etc.). Social Outcomes entail the social reactions which the performance of a certain behavior elicits, e.g., social acceptance, social recognition, etc. Finally, Self-Evaluative Outcomes entail the personal standards adopted by individuals to regulate their behavior, which include self-satisfaction whenever they successfully performed the target behavior and self-censure whenever they fail to perform the target action.

Social Support. Social Support is the support a person receives from society (e.g., friends and family) towards performing a target behavior. According to Bandura [66], the evolution of health promotion models has come to regard the individual's behavioral change as occurring in an environment of social influence, with high risk behaviors requiring more social support. Noting that health is the product of a complex interplay among self-regulatory influence, biological and socio-structural influences, Bandura [66] calls on society to alter the practices of social systems that are detrimental to health and foster those that improve it. Social Support can be fostered through verbal persuasion, e.g., through encouragement got from others such as a coach psyching up players to increase their self-efficacy. Moreover, it can be fostered through vicarious experience, i.e., through the observation of the successes and failures of similar others performing the target behavior (e.g., role models, behavior models) [96][97][98].

Physical Environment. This refers to the physical environmental conditions and systems (e.g., neighborhood, recreational facilities, transportation systems, etc.) that facilitate or impede the performance of a target behavior. Research [99][100] shows that proximity to exercise equipment, availability of walking/cycling tracks, safe and secure neighborhoods, etc., influence the physical activity level of individuals.

2.2 Persuasive Technology

PTs are interactive applications that are intentionally designed to change attitudes and behaviors in a positive way through persuasion and social influence without deception or coercion [21]. In the last two decades, research in different domains has shown that PTs, if well implemented, have the potential to bring about the desired behavior change. Given that PT employs computers to change behaviors, it is technically called "Captology," which means "*the study and design of computers as persuasive technologies*" [39]. Specifically, the term "Captology" was coined from the phrase "Computers As Persuasive Technologies" by Fogg [21], the pioneer of the field of PT. Hence, as shown in Figure 2.3, PT can be broadly defined as the use of computers and persuasive techniques from Social Psychology to change attitude and behavior or foster compliance [21].

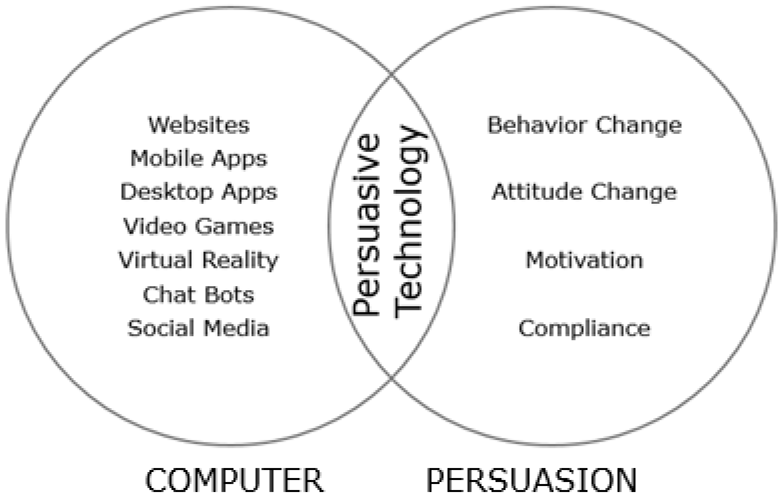

Figure 2.3: Persuasive Technology also known as *"Captology"* [101]

Examples of computer applications for changing attitude and behavior include desktop and mobile apps (e.g., fitness apps), social media (e.g., Twitter, Facebook, etc.), video games (e.g., persuasive games in education), etc. All of these socio-technical media and applications—for example, in the health domain [102][103][104]—have the potential to influence user attitudes and behaviors through computer-driven persuasion and/or social influence. However, despite the fact that attitude and behavior change theories from Social Psychology have been extensively employed to study user intentions and behaviors, these theories have been mainly restricted to the prediction of user acceptance of information systems and behaviors in non-actual-use contexts. They have been sparsely used in a systematic fashion for the design and evaluation of PHAs in the field [61]. As such, part of the objective of this dissertation is to demonstrate the process of using empirical models of behaviors grounded in Social Psychology, in the context of personalization, to inform, design and evaluate persuasive health interventions aimed at motivating behavior change in the physical-activity domain.

2.3 Technology Adoption Model

Technology adoption is a process that involves the *acceptance* and *use* of a new technology by its target users. According to Renaud and Van Biljon [53], "*[t]echnology adoption is a process—starting with the user becoming aware of the technology, and ending with the user embracing [accepting] the technology and making full use*

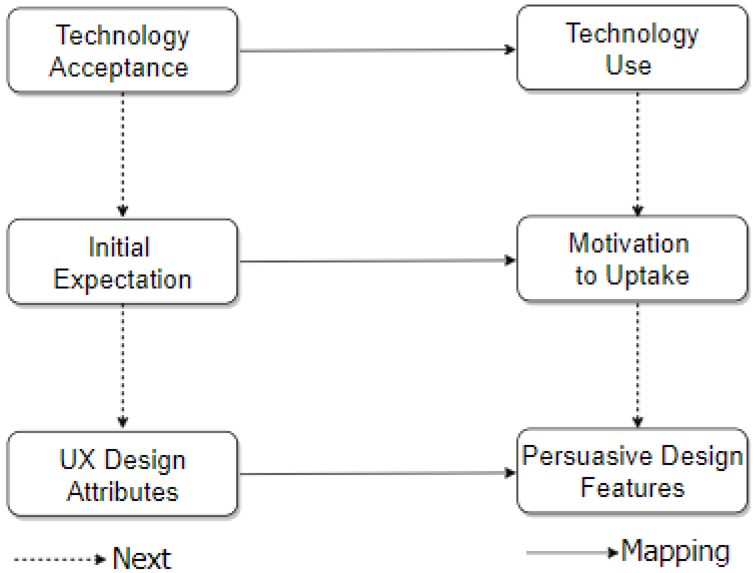

Figure 2.4: Technology Adoption Model (adapted from [60])

of it." In other words, for we to say that the target users have adopted a PT, they have to accept it as well as use it to inform their behavior change ultimately. Figure 2.4 shows a simple representation of the Technology Adoption Model. The first stage in the model entails the TAM. According to Pinpathomrat [60], before a user takes up a new technology such as an information system, an initial expectation is created, which—in the context of the traditional TAM—entails *performance expectancy* and *effort expectancy*. Secondly, based on their level of both expectancies, users are motivated towards the uptake (i.e., use) of the technology.

In general, the first stage of the Technology Adoption Model, which Pinpathomrat [60] regarded as *initial expectation*, can be mapped to the *UX design attributes*, which in the context of TAM, influence the *acceptance* of a new technology. Moreover, the second stage of the Technology Adoption Model, which Pinpathomrat [60] regarded as *motivation to uptake*, can be mapped to the *persuasive design features*, which in the context of TUM, influence the *use* of a new technology. In the traditional sense of the TAM, users will adopt the technology if they have a high initial expectation and a high motivation towards its use [60]. Specifically, users will accept the new technology if they believe that it will improve their job performance (*performance expectancy*) and does not require much effort (*effort expectancy*). Moreover, they will use the technology if they are motivated by its persuasive features aimed at facilitating their behavior change.

2.3.1 Technology Acceptance Model

The TAM models the cognitive processes involved in the acceptance of a new technology by potential users. Proposed by Davis et al. [57], it was based on Fishbein and Ajzen's [105] Theory of Reasoned Action, which is a well-established casual chain model (beliefs → attitude → intention → behavior) that explains the link between *beliefs*, *attitude*, *intention* and *behavior* [58]. As shown in Figure 2.5, the TAM holds that the *actual use* of an information system is determined by its potential users' *intention to use* the system, which in turn

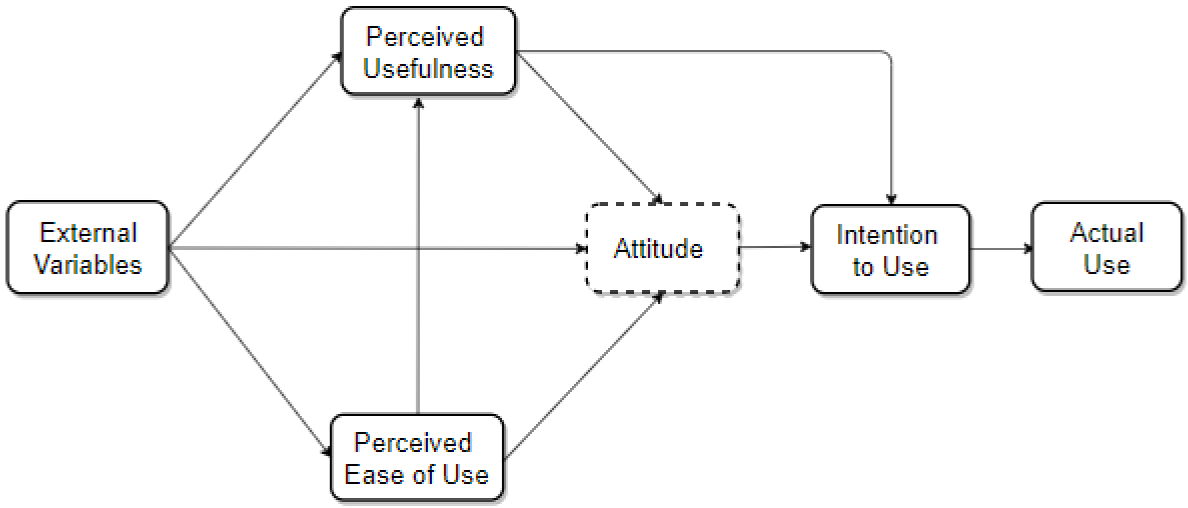

Figure 2.5: Technology Acceptance Model (adapted from[106])

is determined by their *attitude* towards (using) the system. Moreover, the TAM holds that users' *attitude* towards (using) the information system is determined by two main beliefs (initial expectancies): *perceived usefulness* and *perceived ease of use*. *Perceived usefulness* refers to "*the degree to which a person believes that using a particular system would enhance his or her job performance*" (p. 320). Moreover, *perceived ease of use*, also known as *perceived usability* in the Human-Computer Interaction (HCI) domain, refers to "*the degree to which a person believes that using a particular system would be free from effort*" (p. 320) [106].

Research [55] has shown that *perceived usefulness* has a stronger effect on *attitude* than *perceived ease of use*. In other words, *perceived usefulness* is a better predictor of *attitude* than *perceived ease of use*. In the original TAM, Davis et al. [57] found that "*perceived usefulness strongly influenced people's intentions, explaining more than half of the variance in intentions*" (p. 982). *Attitude*, in particular, partially mediates the influence of *perceived usefulness* and *perceived ease of use* on *intention to use* [57], which in turn directly influences the *actual use* of the information system. Finally, the TAM holds that *perceived ease of use* and *perceived usefulness* are influenced by other external characteristics/attributes (e.g., *perceived aesthetics*, *perceived credibility*, etc.) of an information system, which are basically users' beliefs about the target system [107]. Moreover, *perceived ease of use* and *perceived usefulness* serve as mediators of the effect of the other system characteristics on *intention to use* [55].

It is noteworthy that authors such as as Venkatesh and Davis [55] and Venkatesh et al. [52] found that *attitude* is of less importance in the TAM. Thus, to achieve parsimony, it was excluded from some of the later TAMs by a number of authors [108]. For this reason, the *attitude* construct in the TAM in Figure 2.5 is intentionally represented by dashed lines, indicating it is sometimes excluded from the structural equation model by some authors. That said, in the extended TAM presented in this dissertation, called Persuasive Technology Acceptance Model (PTAM), *attitude* is replaced by *perceived persuasiveness*, which Lehto et al. [109] and Drozd et al. [110] found to be a proximal determinant of the *intention to use* a persuasive system.

2.3.2 Technology Use Model

The TUM models the persuasive features that explain the use of a new technology. Figure 2.6 shows a multi-choice representation in the context of PT. The path model shows that persuasive features have the potential to predict (explain) the use of a PHA. Such persuasive features, also known as motivational affordances, include Goal-Setting, Reward, Competition, etc., which are commonly employed in PT design to motivate behavior change [15][61]. Moreover, they can be viewed as lower-order constructs representing a higher-order construct—*perceived usefulness*—which is a predictor of *intention to use* in the TAM [55][58]. In the extant literature, these features have been scarcely studied as possible predictors of the *intention to use* a PT.

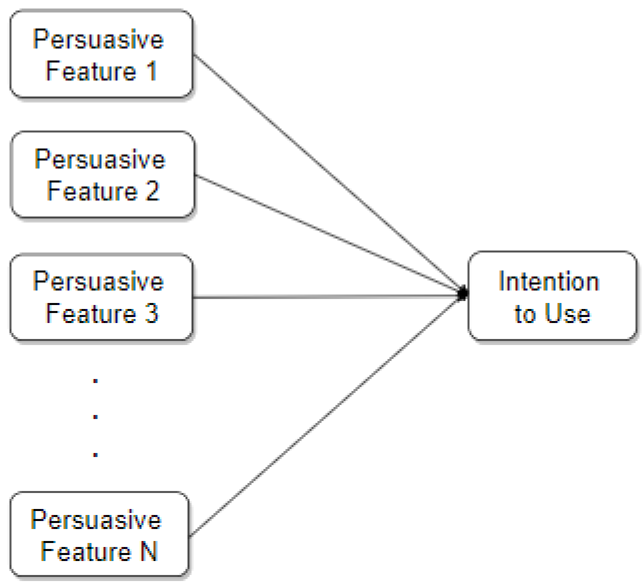

Figure 2.6: Persuasive Technology Use Model

2.4 Mapping of TAM to Captology

The TAM can be compared to Captology as shown in Figure 2.7. Captology is a terminology coined from the interaction between "computer" and "persuasion" (i.e., "technology" and "persuasion"). As a result, it is defined as the use of computers to change attitudes and/or behaviors through persuasion. Moreover, the TAM, at a high level, can be conceptualized as comprising two major domains: *system domain* and *user domain*. The system domain is concerned with the "attributes of the system," such as *perceived ease of use* and *perceived usefulness*, which influence the acceptance and/or adoption of the system. On the other hand, the user domain is concerned with "behavior change," relating to system adoption. Specifically, it is concerned with the users' attitude, their intention to and actual use of the system. As shown in Figure 2.7, the "system domain" in the TAM can be mapped to the "computer" component in Captology, while the "user domain" in the TAM to the "persuasion" component. Therefore, in the light of Captology, the TAM can be conceived as the use of system design (i.e., user experience (UX) design) attributes such as *perceived*

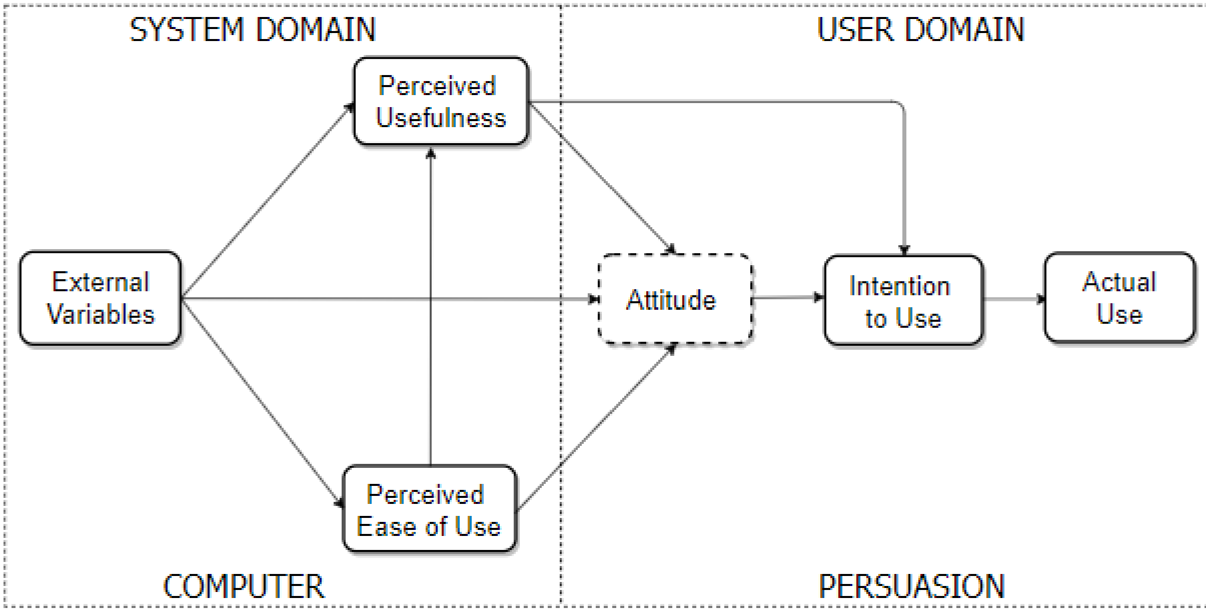

Figure 2.7: Mapping of the TAM to Captology (adapted from [106])

usefulness and *perceived ease of use* to influence users' *attitude* and *intention to use* a system. In the context of PT, I refer to my extended TAM, which includes UX design attributes (such as *perceived aesthetics*) and *perceived persuasiveness* (a proxy for *attitude*), as PTAM.

2.5 Persuasive Design Frameworks

A number of persuasive design frameworks have been proposed for the design and evaluation of PT interventions aimed at changing behavior. However, Fogg's [111] PT design framework and Oinas-Kukkonen and Harjumaa's [61] persuasive system design (PSD) framework are the two most common used [30].

2.5.1 Fogg's Persuasive Technology Design Framework

In an attempt to provide PT design guidelines for developing successful PTs, Fogg [111] proposed a PT design framework. The framework is an eight-step design process, which can be utilized in designing PT interventions through the imitation of existing PTs on the market or in the literature that are considered successful. The eight steps in Fogg's PT design framework are presented as follows.

Step 1. Choose a simple behavior to target. This step entails choosing a target behavior that is simple to change. A big goal should be reduced to a small goal, which is clearly stated. Moreover, a large, vague and complex goal should be broken down into small, clear and simple ones, with each taken at a time.

Step 2. Choose a receptive target audience. This step involves selecting a target audience that is likely or willing to accept the intervention to change the target behavior. In addition, as much as possible, the target audience should be familiar with the technology channel of intervention.

Step 3. Find what prevents the target behavior. This step entails investigating the barriers that prevent the target users from performing the target behavior. According to Fogg Behavior Model [112], such barriers include lack of motivation, lack of ability, and lack of a well-timed trigger (i.e., cue or prompt).

Step 4. Choose a familiar technology channel. This step involves selecting the best technology channel to deliver the intervention, which depends on three factors: the target behavior, the target audience and the barrier preventing the target audience from adopting or performing the behavior. Examples of technology channels include web, mobile, video game, texting, etc. The designers are expected to choose the channel that is familiar to the audience as well as makes the target behavior easy to perform. Step 4 and each of the other three earlier steps can occur in the reverse order. For example, step 4 can occur before step 1 and vice versa. However, for the most part, step 4 can only be carried out after steps 1, 2 and 3 have been completed. In addition, the first four steps should be carried out, in whatever sequence that is appropriate for the designers given their various constraints, before the next four steps.

Step 5. Find relevant examples of persuasive technology. This step requires that the designer search the literature and/or marketplace for examples of PTs that have been successful. In this step, making informed guesses might be necessary as companies whose PTs have been successful may not be willing to share their data with the public in order to be ahead of the competition.

Step 6. Imitate successful examples. This step involves selecting and imitating one of the successful examples identified in step 5. Imitating successful examples prevent designers from reinventing the wheel by starting from scratch, thereby saving them time, effort and resources.

Step 7. Test and iterate quickly. This step involves prototyping and piloting various versions of the selected example which the designers have chosen to imitate. In particular, this step helps the designer to determine which of the tested versions is most effective based on the users' feedback.

Step 8. Expand on success. This step involves scaling up the successful version of the selected example piloted in step 7. Scaling up can be carried out in four ways: (1) making the target behavior more difficult; (2) reaching out to a broader target audience; (3) targeting a different audience altogether; and (4) targeting a different behavior altogether. It is expected that the scaling process should be carried out in a systematic fashion by varying only one or two of the four ways of scaling at a time.

2.5.2 Oinas-Kukkonen and Harjumaa's Persuasive System Design Model

Oinas-Kukkonen and Harjumaa [61] proposed a PSD framework (also known as the PSD model) for the design and evaluation of persuasive systems. The PSD model (Figure 2.8) outlines three steps for the development of persuasive systems for behavior change. They include the following: (1) understanding the key issues behind the persuasive context; (2) analyzing the persuasion context; and (3) selecting the design features for the implementation of the persuasive application.

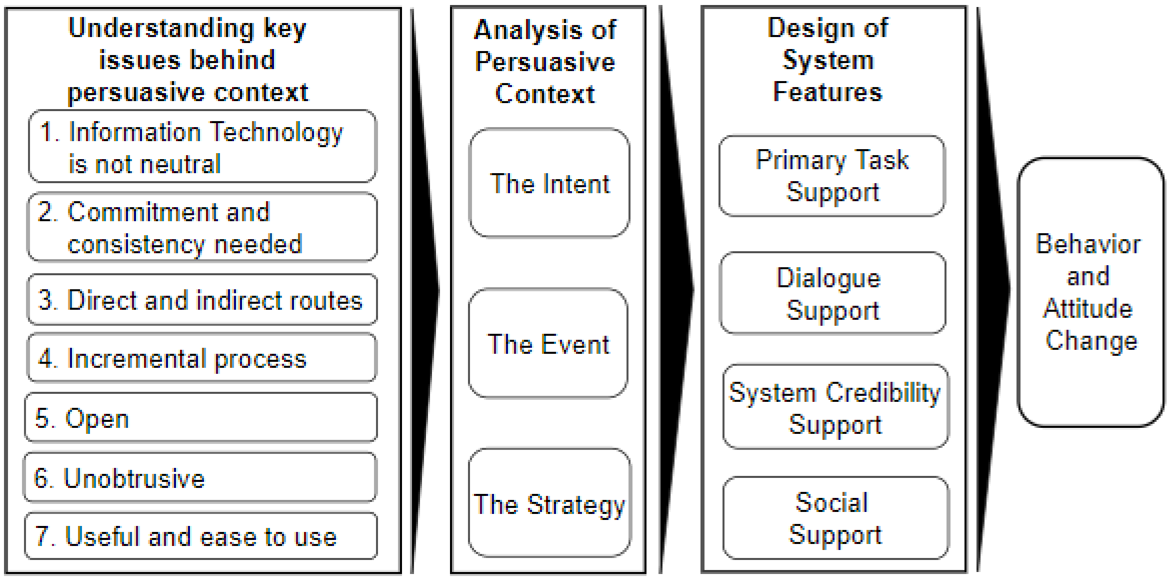

Figure 2.8: Oinas-Kukkonen and Harjumaa's framework for persuasive system development [61]

Phase 1. Understanding the key issues behind the persuasive context. According to Oinas-Kukkonen and Harjumaa [61], "*it is crucial to understand the fundamental issues behind persuasive systems before implementing the system. Only after obtaining a reasonable level of this understanding can the system be analyzed and designed*" (p. 486). Thus, in the first phase of the persuasive system development, key issues, which the authors present as postulates, must be analyzed and well understood. These key issues include the following [61]: (1) Information technology is never neutral; (2) People like their views about the world to be organized and consistent; (3) Direct and indirect routes are key persuasion strategies; (4) Persuasion is often incremental; (5) Persuasion through persuasive systems should always be open; (6) Persuasive systems should aim at unobtrusiveness; and (7) Persuasive systems should aim at being both useful and easy to use.

The first postulate means that information technology is never neural: it is always aimed to influence the attitudes and behaviors of people in one way or another. The second postulate (people wanting their views about the world to be organized and consistent) is grounded in the idea of commitment and cognitive consistency postulated by Cialdini. For example, if a persuasive system supports goal-setting, the target users will be more likely persuaded. The reason is that people like their future actions to be consistent with their commitments. The fifth postulate has to do with persuasive systems being transparent and avoiding the use of deception to increase persuasiveness. The sixth postulate has to do with understanding the opportune and inopportune moments at which certain persuasive strategies should be and not be used, respectively. The seventh and last postulate states that persuasive systems should have useful features and be easy to use.

Phase 2. Analyzing the persuasion context. In this phase, the persuasion context, comprising three components (*intent*, *event*, and *strategy*), is analyzed. The intent comprises the persuader (designer) and the change type the persuader ought to achieve. For example, "*does the designer of the persuasive system intend* *to change attitude or behavior, a one-time or permanent behavior?"* The intent of the designer will determine the persuasive strategy (i.e., the path to persuasion) s/he will adopt. If, for instance, the designer aims at changing a one-time behavior, then the direct path to persuasion, which requires less users' thought and cognition, will be targeted. However, if the designer aims at changing a permanent behavior, then the indirect path to persuasion, which requires more users' thought and cognition, will be targeted so the behavior change can be long-term. Lastly, the event relates to understanding the *use*, *user* and *technology contexts*, about which certain questions (that determine the system features) must be asked and answered. For example, regarding the use context, "*is the persuasive system being designed for healthy eating or physical activity or smoking cessation?*" Regarding the user, "*is the persuasive system being designed for children or for adults?*" Secondly, "*What are the target group's determinants of the target behavior, preferences and needs?*" Lastly, regarding the technology, "*is the persuasive system going to be deployed on the mobile or desktop platform or both.* The authors argued that these questions ought to be addressed for a successful PT to be realized.

Phase 3. Selecting the design features for the implementation of the persuasive application. Finally, in the third phase, the actual system features are selected and analyzed for the design of the new persuasive system. The features are grouped into four categories (primary task, dialogue, system credibility and social supports). They are employed not only as design principles to develop a persuasive system but to evaluate the fully designed system or an existing system. The PSD model provides some guidelines on how the design principles in each category can be mapped to the implemented features in persuasive systems.

Table 2.1 shows the primary task category, which features eight essential design principles and example implementations in a fitness application. Each of the design principles facilitates the performance of the target behavior. They include Reduction, Tunneling, Tailoring, Personalization, Self-Monitoring, Simulation, and Rehearsal. For example, Reduction can be implemented in a fitness application by simplifying a complex behavior for easy performance by the target user. A typical example is modifying floor-based push-up to a chair-based push-up for elderly people and beginners.

Table 2.1: PSD model's Primary Support principles and implementations (adapted from [61])

Design Principle	Example Implementation in a Fitness Application
Reduction	Simplify a complex behavior for easy performance, e.g., modify floor-based push-up to a chair-based push-up for elderly people and beginners.
Tunneling	Break down the steps (body positions and movements) it takes to perform a given bodyweight exercise, e.g., push-up, which people may find difficult to perform at first.
Tailoring	Provide different workout plans to different groups of users, e.g. beginner and advanced.
Personalization	Personalize content to users based on certain psychosocial factors, e.g., ability, age, gender.
Self-Monitoring	Track user's daily step count and exercise, including calories burned and duration of activities.
Simulation	Show users simulated models of themselves losing weight after exercising for a given period.
Rehearsal	Allow users to rehearse with the aid of the app without the exercises being logged.

Table 2.2 shows the Dialog Support category of design principles and example implementations. It refers to the feedback (e.g., textual, visual, audio, etc.) provided by a persuasive system to motivate the user to perform a target behavior. These different forms of feedback include Praise, Rewards, Reminders, Suggestions, Similarity, Liking and Social Role.

Table 2.2: PSD model's Dialog Support principles and implementations (adapted from [61])

Design Principle	Example Implementation in a Fitness Application
Praise	Congratulate or applaud users for achieving a certain goal, e.g., 10,000 steps a day.
Reward	Award users a trophy for achieving all of their weekly goals, e.g., in one-month period.
Reminder	Send notification to users as reminders to exercise on days they committed to.
Suggestion	Suggest to users beneficial tasks at the right time/place, e.g., take the stairs in lieu of elevator.
Similarity	Provide behavior models similar to the physical characteristics of the users, e.g., race, gender.
Liking	Provide behavior models that are physically fit and attractive.
Social Role	Provide users with a virtual coach as a personal trainer.

Table 2.3 the System Credibility Support category of design principles and example implementations.. It entails the need for the interface of a persuasive system to be designed credibly and professionally to increase its effectiveness. The system credibility design principles include Trustworthiness, Expertise, Surface Credibility, Real-Word Feel, Authority, Third-Party Endorsements and Verifiability.

Table 2.3: PSD model's Credibility Support principles and implementations (adapted from [61])

Design Principle	Example Implementation in a Fitness Application
Trustworthiness	Provide correct, relevant and reliable health information to users.
Expertise	Update app regularly to meet the state of the art, with bugs fixed as early as possible.
Surface Credibility	Provide correct information and support limited number of relevant adverts.
Real-World Feel	Provide a means for users to provide feedback to the designers and ask questions.
Authority	Provide health information from health authorities such as WHO, e.g., its minimum recommended MET-mins/week required to be active.
Third-party Endorsement	Show professional certifications, e.g., a secure-connection logo to boost users' confidence in the security and privacy of their health data.
Verifiability	Provide links to claims and other authority-based information shown in tha app.

Finally, Table 2.4 shows the Social Support category of design principles and example implementations. It is concerned with employment of social influence to motivate behavior change. The seven design principles in this category include Social Learning, Social Comparison, Normative Influence, Social Facilitation, Cooperation, Competition and Recognition.

Table 2.4: PSD model's Social Support principles and implementations (adapted from [61])

Design Principle	Example Implementation in a Fitness Application
Social Learning	Notify users about the achievement of their partners (e.g., meeting a set goal).
Social Comparison.	Allow users to see one another's performance and contribution made to the collective goal.
Normative Influence	Show users weight-loss results of others who followed recommended workout plans.
Social Facilitation	Allow users to know about other users doing their workout at the same time as them.
Cooperation	Allow users in a group setting to set collective goals and work together to achieve them.
Competition	Employ a leaderboard to foster competition among users that are challenging one another.
Recognition	Reward or acknowledge users who have succeeded in losing substantial weight in the group.

2.6 Theory-Driven Persuasive System Design

In Fogg's eight-step design process and Oinas-Kukkonen and Harjumaa's [61] PSD model for persuasive system design, it is obvious that they do not consider theory despite the fact they emphasize the need to understand the target users. In particular, they do not provide specific guidelines on how to design theory-driven persuasive systems based on behavioral determinants. For this reason, it becomes difficult to evaluate such systems in terms of understanding the theoretical basis of what worked and did not work in a PT intervention. As a result, Michie et al. [63] proposed a theory-driven intervention design framework by drawing on Hardeman et al.'s [36] work on causal modeling. According to Michie et al.'s [63], there are three main reasons for designers to use theory in designing interventions. They include the following:

1. Interventions are more likely to be effective if the causal determinants of behavior are targeted;
2. Theory can only be tested and developed further through the evaluations of interventions in experimental settings if the interventions and evaluations, in the first place, are theoretically informed.
3. Theory-based interventions foster an understanding of what worked and did not work, which provides a basis for the refinement and improvement of theory across different populations and contexts.

For the above reason, Michie et al. [63] proposed a three-step theory-driven intervention design framework as shown in Figure 2.9. The steps include the following:

1. Step 1: Identify behavior determinants grounded in existing theories of behavior change;
2. Step 2: Identify behavior change techniques to be implemented in the intervention; and
3. Step 3: Identify the link between behavior determinants and behavior change techniques.

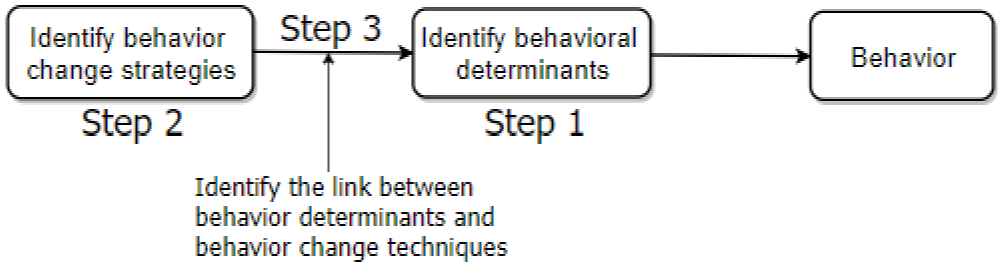

Figure 2.9: Michie et al.'s theory-driven intervention design framework (adapted from [30][63])

In the Michie et al.'s [63] framework, the first step in the design of a theory-driven intervention is to identify the target group's determinants of behavior. This step can be achieved in two phases: (1) selecting an appropriate behavior change theory from the literature (e.g., through a systematic review) to model the target group's determinants of behavior; and (2) conducting an empirical study to build the causal model of the target behavior of the target group. The second and third steps entail the mapping of the theoretical determinants of behavior onto behavior change techniques (persuasive strategies) in the application domain. Again, the information on the link between behavior determinants and persuasive strategies can be drawn from the literature, as there has been a large body of work on this area (e.g., [31], [63], [113]). For example, in the context of SCT, Yoganathan and Kajanan's [113] proposed a mapping of four of the important social-cognitive constructs (Self-Efficacy, Self-Regulation, Outcome Expectation and Social Support) to persuasive strategies in the application domain. Self-Efficacy was mapped to Reduction and Tunneling; Self-Regulation to Self-Monitoring and Tailoring; and Outcome Expectation to Suggestion, Simulation and Reward. Finally, Social Support was mapped to social strategies such as Competition, Cooperation, etc.

Although Michie et al.'s [63] framework has been adopted by a number of researchers (e.g., Orji [30], in the eating domain) to design theory-driven interventions in the PT domain, it has some limitations. For example, it does not provide the basis for selecting specific behavior change techniques in the event that the target group has several significant behavior determinants (mapped onto corresponding behavior change techniques) and the designer will have to make choices. Although not shown in the framework, a fourth step in the design of the theory-driven intervention entails selecting the specific behavior change techniques to be implemented in the intervention. The selection of strategies may be necessary for a number of reasons, including limited implementation resources, reducing cost and roll-out time of technology-driven interventions. As a result, the designer may have to base the selection of behavior change techniques to be implemented on non-validated guesses and/or behavior determinants. Specifically, the Michie et al.'s [63] framework did not include a step on the validation of the behavior change techniques in the application domain. This step would have allowed for the triangulation of the behavior determinants in the theory domain with users' receptiveness to the preselected behavior change strategies in the application domain. Thus, in this dissertation, I proposed a seven-step PT design framework, called "EMVE-DeCK Framework," which encompasses the validation of behavior determinants (mapped to preselected persuasive strategies) in the application domain.

2.7 Personalization

Research [26][32] has shown PTs are more likely to be successful if they are personalized to the target audience. Personalizing persuasive technologies, simply known as personalization, is "*the act of tailoring persuasive technologies to the target audience to increase their relevance, motivational appeal, and hence their overall effectiveness [in changing behavior]*" (p. 2) [114]. Basically, there are two types of personalization: *group-based* and *individual-based* (see Figure 2.10) [29]. The former is often referred to as tailoring, while the latter is simply referred to as personalization.

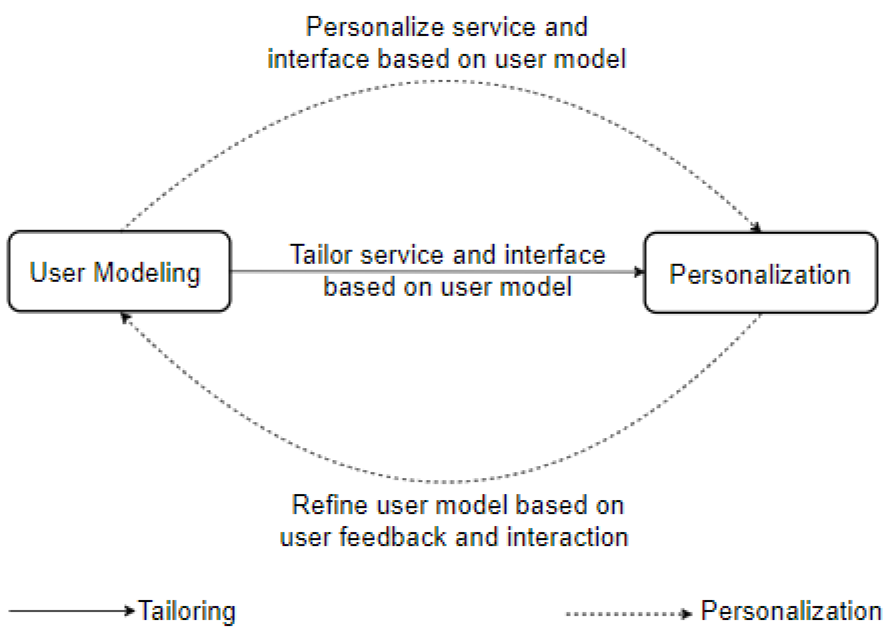

Figure 2.10: Personalization at group and personal levels (adapted from [29])

Tailoring (also known as low-level personalization [29]) is a one-off act implemented at design time that targets a given user group with similar demographic characteristics (e.g., gender, age, culture, race, etc.). The user-group profiles and models are predetermined, e.g., through questionnaire-based user studies, and are used to tailor the service and interface of the persuasive application to the target user group. On the other hand, individual-based personalization (also known as high-level personalization [29]) is an on-going process that targets the individual. The user model is determined in real time through the user's interaction with the persuasive application and provided feedback. This information gathered from the user while using the application is then used to personalize services and the user interface to him/her to increase the chances of his/her performing the target behavior. In this dissertation, I adopted group-based personalization to tailor my proposed PHA to the target users. Group-based personalization can be achieved in two main ways: *user modeling* and *user profiling*, which I briefly discuss in the following subsections.

2.7.1 User Model

User model is a conceptual model of users so that technology can be best adapted to users' needs, preferences, interests and feedback [115]. Thus, user modeling is the process of building, modifying and selecting the best conceptual models to describe users. There are different types of user models, which include static, dynamic, stereotype-based and highly adaptive [116][117]. This dissertation is based on static models. A static model is a fixed model of the user (e.g., his/her preferences, needs, behavior determinants, etc.) at design time, which is used to personalize the look and feel and/or behavior of a system to him/her at use time. This type of model is contrasted with dynamic models. A dynamic model is a real-time updatable model of the user, which is used to personalize the look and feel and/or behavior of a system to him/her at use time. The main difference between static and dynamic modeling is that the former is carried out prior to using the persuasive system, while the latter is done in the course of using the system [118].

2.7.2 Users' Persuasion Profile

Persuasion profile is a collection of numerical estimates of a given target group's or individual's levels of receptiveness to a set of persuasive strategies [26]. There are two main persuasion profiles that are employed in the personalization of persuasive systems to the target users. They include *explicit* and *implicit* persuasion profiling. Explicit profiling is a meta-judgmental measure of the receptiveness of an individual or a user group to a subset of persuasive strategies. It is based on the scores of users' response to standard questionnaires. On the other hand, implicit profiling is an operational measure of the characteristics of the user. It is based on the interactions of the user with an actual system and/or the user responses to persuasive attempts in an actual system. The real-time information gathered from users' interaction and responses to persuasive attempts are used to adapt the persuasive system to the user and personalize future interactions [26]. Explicit profiling and implicit profiling are the equivalents of static and dynamic modeling, respectively. Personalizing persuasive systems based on explicit profiling can be employed in low-level personalization (for a group) as well as in high-level personalization (for the individual), only that the user profile is learned prior to the actual use of the system. On the other hand, personalizing persuasive systems based on implicit profiling can be regarded to as a form of high-level personalization, in which the user model is learned in the course of using the system. In this dissertation, I adopted the explicit profiling method.

2.7.3 Culture-Based Tailoring

To be able to design an effective PT intervention, there is a need to investigate the behavioral determinants, persuasion profiles, user models, preferences and requirements of the target audience. Research has shown that demographic variables (e.g., culture, age and gender), used to segment target populations, influence user preferences, perceptions and judgments of user interfaces in UX design [45][119][120] and receptiveness to persuasive strategies in PT design [121][122][123]. In this dissertation, I focus, specifically, on the influence of culture, based on which I tailored the PT intervention to the target populations. Culture is defined as a collective way of life, which includes thinking, feeling, acting, etc. It varies from one group of people to another based on categorizations such as locality, organization, region, country or continent. It helps in shaping the beliefs, language, dressing, food, etc., of a group of people living together within a certain social environment. According to Hofstede et al. [124], culture is learned and not innate; it derives from the social environment of a people and not their biological genes. Research in HCI shows that "*users from different cultural backgrounds do not share the same beliefs and perceptions towards an HCI system*" (p. 630) [49]. In the PT subdomain, research [121][122][125] also shows that culture influences users' receptiveness to persuasive strategies and PT interventions. Thus, there have been several calls from a number of scholars in the research community [26][45][49] for the need to tailor HCI systems to cater to the cultural values and preferences of the target populations. In the Social Psychology and Sociology literature, different frameworks [126] for studying culture have been proposed (e.g., [41], [46], [127], [128], [129]). Among them, Hofstede's [41] and Hall's [46] cultural dimensions are the most commonly employed frameworks in cross-cultural research [47] in general and HCI research [48][49][130] in particular. However, in this dissertation, I focus on the Hofstede's cultural framework, which is mostly employed in PT research aimed at motivating behavior change [31][50][51].

2.7.4 Hofstede's Cultural Framework

Hofstede [131] is one of the pioneer researchers of culture on the global front. He conducted a comprehensive study on how culture influences workplace values using the employees of International Business Machines (IBM) in over 50 countries. Based on this study, he classified culture into six dimensions: *power distance*, *masculinity vs. femininity*, *uncertainty avoidance*, *long- vs. short-term orientation*, *indulgence vs. restraint*, and *individualism vs. collectivism* [41][131].

Power Distance. Power distance is a measure of how different cultures view and accept power relationships between people in different domains and human endeavors. While some countries practice a low power-distance culture, others practice a high power-distance culture, for example, in parent-child, teacher-student, boss-subordinate and authority-citizen relationships and roles. For example, in low power-distance culture, parents view and treat their children as co-equals. However, in high power-distance culture, parents see themselves as superiors and authorities to their children. As a result, they teach their children to be obedient and respectful. Moreover, in low power-distance culture, subordinates expect to be consulted. However, high power-distance culture, subordinates expect to be told what to do. According to Hofstede's Power Distance Index, countries in Eastern Europe, Latin America, Asia and Africa tend to rank higher, while countries in Western Europe and North America tend to rank lower [41][131].

Masculinity vs. Femininity. In the context of culture, masculinity represents a society's preference for achievement, heroism, assertiveness and material success. On the other hand, femininity represents a society's preference for cooperation, modesty, quality of life and caring for the weak. While, in masculine culture, men are expected to be assertive, ambitious, tough and competitive, in feminine culture, both men and women are expected to be modest. German-speaking countries, Japan and some Latin American countries such as Mexico tend to rank high in masculinity, while Nordic countries and Netherlands tend to rank low in masculinity. In the former, the gender wage gap is large, while, in the later, it is small [41][131].

Uncertainty Avoidance. The uncertainty avoidance dimension is also known as risk avoidance. It deals with the amount of stress in an unpredictable situation that a given society is willing to undergo. In other words, it is the amount of comfort or discomfort a given society is willing to experience in an unstructured situation. It is characterized as weak or strong. For example, in a weak uncertainty avoidance culture, the inherent uncertainty that characterizes life is accepted and taken each day as it comes. However, in a strong uncertainty avoidance culture, it is fought because it is viewed as a threat to life. Uncertainty avoidance tends to be higher in Eastern and Central European countries, Latin countries and German-speaking countries, and lower in English-speaking, Nordic and Chinese culture countries [41][131].

Long- vs. Short-Term Orientation. The long- vs. short-term orientation dimension refers to the level of stress in the face of an unpredictable future that a given society is willing to undergo. Examples of long-term oriented countries in decreasing order include Eastern Asian countries and Eastern and Central European countries. On the other hand, examples of short-term oriented cultures include United States and Australia, Latin American, African and Muslim countries [41][131].

Indulgence vs. Restraint. Indulgence, on one hand, characterizes a society that allows the free gratification of basic and natural human desires such as enjoying and having fun in life. Restraint, on the other hand, characterizes a society that controls or regulates the gratification of human needs and desires by means of strict social norms. As such, in an indulgent culture, freedom of speech is viewed as a fundamental human right. On the other hand, in a restraint society, freedom of speech is hardly viewed as a fundamental human right. Examples of indulgent cultures include South and North America, Western Europe and parts of Southern Africa, while examples of restraint cultures include Asia and the Muslim world [41][131].

Individualism vs. Collectivism. Individualism is the world view of the self as an independent entity possessing a set of self-defining attributes, resulting in the expression of personal opinions and beliefs and the pursuits of personal goals and aspirations. Thus, in this type of culture, the concept of "I" as a distinct individual takes precedence over the concept of "We" as a collective group. In individualist cultures, everyone has to take care of themselves and their immediate family at most and has the right to privacy. Moreover, the individual's tasks and achievements are expected to prevail over social relationships. As such, the view of the self as independent and the need to prioritize personal interests above collective interests influence how the individual relates with others in the society. For example, the relationships among people are based on the assumption that they have to be made freely and with little or no obligation to the other party involved. Most Western countries, such as United States, Canada, etc., are classified as individualist societies [41][131][132].

On the other hand, collectivism is the world view of the self as an interdependent entity and belonging to an in-group, which members owe an obligation, such as complying with its norms and ethos. In this type of culture, members are expected and obligated to pursue the collective goals and aspirations of the in-group (as opposed to personal goals) through consensus and compromise. Unlike the individualist culture, the concept of "We" as a collective takes precedence over the concept of "I" as an individual. As such, collectivist people put the collective interests ahead of their personal interests. In the in-group, the opinions of others have a strong influence on the decision-making of its members. Moreover, members are bound to be loyal to the leadership of the in-group in exchange for protection and other benefits. Most countries in Africa, Asia and South America (e.g., Nigeria, China, Brazil, etc.) are classified as collectivist societies [41][131][132].

2.7.5 Justification for Choosing Hofstede's Cultural Framework

Although several frameworks and dimensions have been proposed in the literature to explain culture, in HCI and PT research, Hofstede et al.'s framework, especially the *individualism* vs. *collectivism* dimension, has been the most widely used [133]. The individualism vs. collectivism dimension has been found to explain most of the variance in global differences [50][134]. Thus, several studies in the HCI domain (e.g., [49], [135], [136]) and PT domain (e.g., [31], [50], [51]) employed and continue to employ the Hofstede's [124] individualism vs. collectivism dimension in carrying out cross-cultural research on user interface design preferences and persuasive strategies, respectively. Given that many existing studies in the HCI and PT domains have used and validated this cultural dimension, I decided to choose it as the cultural framework on which the cross-cultural user studies in this dissertation would be based. A second reason why I chose the individualism vs. collectivism dimension is that the two target populations for my research—Canada/United States (individualist) and Nigeria (collectivist)—vary the most in this cultural dimension as shown in Figure 2.11. Specifically, the difference between Nigeria and Canada/United States in the individualism dimension is 61/50 (the highest), compared with the difference in the power-distance dimension (41/40 - the second highest difference) and the masculinity dimension (8/2 - the least difference). Moreover, I combined Canada and United States as one cultural group because they do not vary much in the six Hofstede's cultural dimensions of culture. Specifically, both countries are usually on the same side of the six cultural dimensional spectrums or close together. Regarding each dimension, they are either below an index of 50 (e.g., in power distance and long-term orientation), or around 50 (the middle or neutral value, e.g., in uncertainty avoidance), or above 50 (e.g., in the individualism dimension). A third reason for choosing the individualism vs. collectivism dimension is that it can be easily mapped to Hall's [46] low-context vs. high-context dimensional classification of culture, respectively [136][137], which is often employed in HCI research (e.g., [120], [138], [139]) as well. A low-context culture is that type of culture which communicates in an explicit manner, leaving little or nothing to be inferred from the context of communication by the receiver. Examples of a low-context culture include Canada and United States, which Hofstede classified as individualist cultures. On the other hand, a high context-culture is that type of culture which communicates in an implicit manner such that much is left unsaid and to be inferred from the context of communication by the receiver. Examples of a high-context culture include Nigeria and China, which Hofstede classified as collectivist cultures [46][119][120].

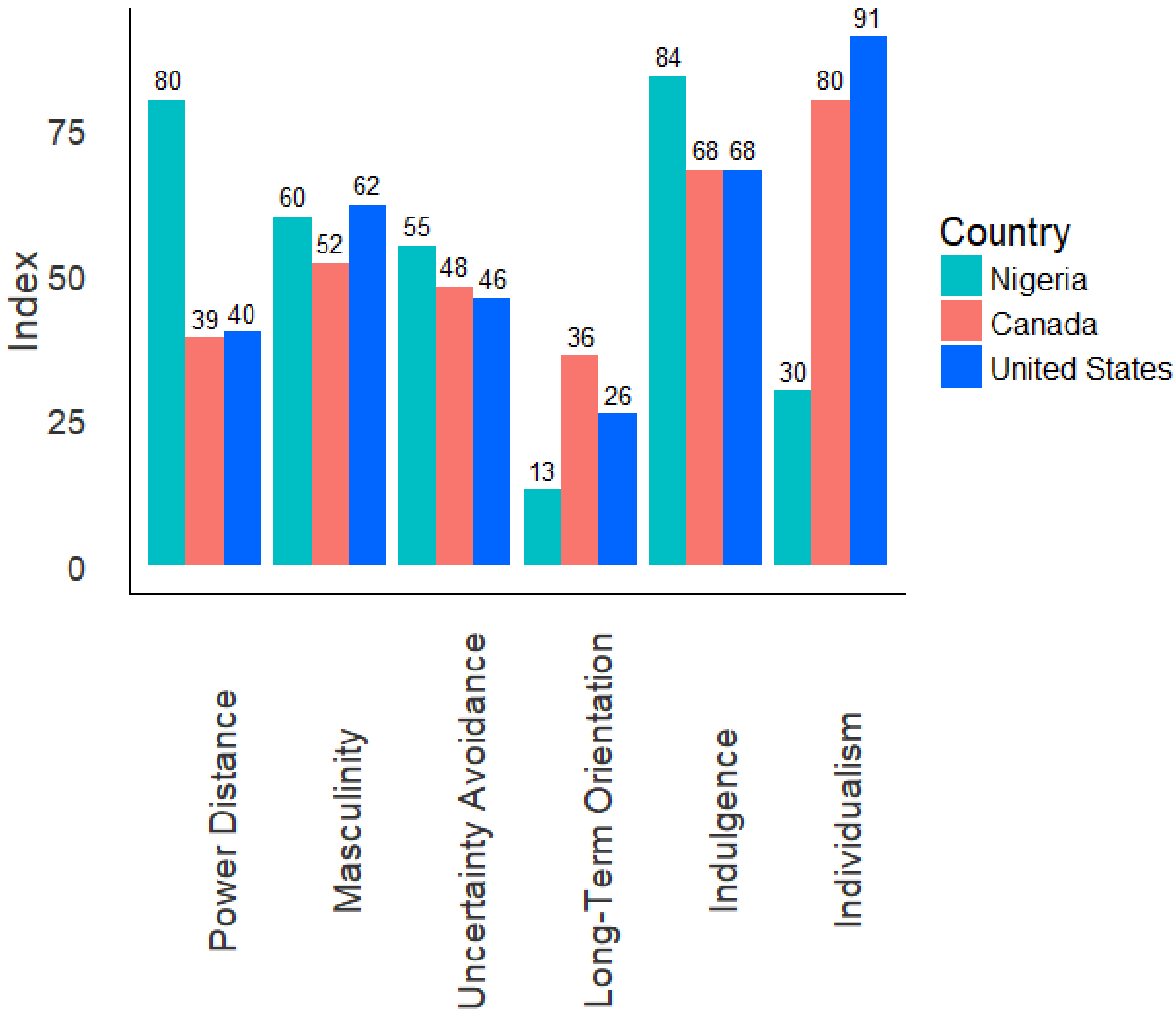

Figure 2.11: Hofstede's cultural dimensional indices for the three target countries [41][124][140]

2.7.6 Criticism of Hofstede's Cultural Framework

Despite its wide adoption in cross-cultural research, Hofstede's cultural framework has received a number of criticisms. For example, his critics argue that Hofstede's framework reduces or equates the concept of culture to nationality without taking into consideration the changes that occur in a group's shared cultural values, social structures and socio-economic development over time. Second, given that Hofstede's dimensions of culture were derived by comparing empirical data from IBM employees across the globe, critics argue that they may not be applicable to other contexts outside the organization [45]. A third argument made against Hofstede's framework is that the original work was conducted in the late 1960's and early 1970's. As such, some critics believe that the results of the studies employed in creating the dimensional indices for the different countries may have changed over time due to social, economic, political and technological factors [141]. However, in response to criticisms, Hofstede later extended his original framework [142] to include additional cultural dimensions from non-IBM employees data, which are publicly available [126]. Moreover, researchers such as Beugelsdijk et al. [143] found that, "*with the exception of Masculinity, Hofstede's dimensions can be replicated using data from the World Values Survey and European Values Study*" (p. 44.) [126]. Although, in HCI research, some researchers (e.g., [144], [145]) have also called the validity of Hofstede's cultural dimensions to question, others have argued and shown that some of the dimensions can be associated with users' design preferences with some degree of success [45]. For this reason and in line with the current practice of conducting cross-cultural HCI research on a national level [45], I based my research on Hofstede's individualism vs. collectivism dimension of culture using Canada/United States and Nigeria, respectively, as a case study. Hence, in the rest of this dissertation, I will refer to the Nigerian group (citizens and residents of Nigeria) as "collectivist" and the Canadian/American group (citizens and residents of either country) as "individualist." Moreover, in certain instances, I use the phrase "individualism vs. collectivism dimension" interchangeably with the broader term "cultural framework."

Secondly, although culture is a complex construct, which cannot be simply defined based on one dimension only, I chose the Hofstede's individualism vs. collectivism dimension for pragmatic reasons. Specifically, my dissertation focuses on commonly employed persuasive strategies in the PT domain (e.g., Goal-Setting, Self-Monitoring, Reward, Cooperation, Social Comparison and Social Learning [33][146][147]) that map very well onto Bandura's [86] social-cognitive determinants of behavior change. For example, persuasive strategies such as individual-based Goal-Setting and Self-Monitoring (which map onto Self-Regulation in the SCT) and Cooperation and Social Learning (which map onto Social Support in the SCT) can be implemented in PTs in correspondence with Hofstede's individualism vs. collectivism cultural dimension, respectively. However, my choice of the individualism vs. collectivism cultural dimension does not preclude other dimensions of Hofstede's cultural framework or cultural theories, in general, from being applied to PT research as theoretical bases to investigate pragmatic ways to personalize persuasive strategies to different target groups. For example, the power-distance dimension in Hofstede's cultural framework may be relevant to the choice of "Authority"—one of Cialdini's [148] universal principles of persuasion—which does not fit into the Hofstede's individualism vs. collectivism dimension. However, Cialdini's persuasive strategies, such as the use of Authority to motivate the behavior change of the target populations, are not part of the focus of this dissertation. Moreover, Hall's [46] low-context vs. high-context cultural dimension can be used as a basis for tailoring the presentation and organization of information in PTs to different target groups that fall under these cultural classifications [120]. However, this research area is not one of the focuses of this dissertation.

Finally, despite all theoretical models are simplified representations of reality, they serve useful purposes in the application domain [149]. This is one of the reasons behind the prevalent simplification of the complex construct of culture to the individualism vs. collectivism dimension of Hofstede's cultural framework in cross-cultural research in the fields of HCI [49][135][136] and PT [31][50][51]. This is also the reason for my reduction of culture to Hofstede's individualism vs. collectivism dimension, which accounts for most of the variance in global differences [50][134]. Specifically, in the PT domain, the simplification serves the pragmatic purpose of personalizing persuasive applications to different target groups based on culture.

2.8 Behavior Change and Types

Research [150][151] shows that there are different types of behavior change with different levels of difficulty in terms of using PTs (also known as behavior change support systems) to achieve them. Thus, PTs ought to be specifically designed with different goals aimed at achieving the different types of behavior change. According to Oinas-Kukkonen [150], there are three types of behavior change, which, in increasing order of difficulty, include compliance-based change (C-Change), behavior change (B-Change) and attitude change (A-Change). All three types correspond to Fogg and Hreha's [151] dot, span and path behaviors, respectively, in Fogg's Behavior Grid. The goal of a persuasive system supporting C-Change is to ensure that the target user complies with a request from the persuasive system once or a finite number of times, e.g., a reminder to exercise at a certain time of the day. Moreover, the goal of a persuasive system supporting B-Change is to elicit a long-lasting change that goes beyond a one- or few-time compliance. While a one-time compliance can be easily achieved, a long-term change (resulting in permanent behavior change) is more difficult to achieve. However, achieving C-Change one or more times may result in B-Change in the long run. Finally, the goal of a persuasive system supporting A-Change is to achieve attitude change along with behavior change. Attitude change has the potential to influence and direct the target behavior; thus, it is the most difficult type of behavior change to achieve by a PT designer. A sustainable B-Change requires an A-Change. As such, full persuasion can only be said to have occurred when attitude change has taken place [150].

In the context of this dissertation, the target behaviors the proposed PT intervention aims to achieve include: (1) the *use of the PHA* to motivate behavior change for a given period, and (2) the *performance of physical activity* at, at least, a moderately active level recommended by the World Health Organization (600 MET-mins/week) [4][7]. Given the different constraints such as limited time to complete my doctoral program and limited funding to compensate participants for taking part in the pilot study for a long period of time, I was only able to evaluate the proposed PT intervention for four weeks. While it is obvious that neither target behavior over a four-week period will result in an A-Change, it is not apparent whether each target behavior should be categorized as C-Change (which occurs many times) or B-Change (which exceeds one-time compliance). That said, based on the definition of both types of behavior change, the four-week users' *use of the PHA* and *performance of physical activity* at a moderately active level can be best regarded as a short-term B-Change. Different metrics are used to measure both target behaviors. For example, regarding *use of the PHA*, Churn Rate (CR) is used to measure the behavior change. CR is defined as the percentage of participants who installed each version of the PHA but did not use it to track their exercise during the four-week period of the pilot study. Moreover, regarding *performance of physical activity*, metrics such as Physical Activity Level (PAL) and Physical Activity Status (PAS) are used to measure the behavior change. PAL is the average of participants' total MET-mins/week. In the implemented PHA (fitness app), each participant's total MET-mins for each week is calculated by summing the walking and exercise MET-mins. Moreover, PAS is the percentage of participants whose average total MET-mins/week is at least 600.

2.9 Gaps in the Existing Literature

The literature review of existing work on the design and evaluation of PT interventions (presented in the individual studies in subsequent chapters) reveals that there are some gaps in the existing body of knowledge, which are yet to be filled.

2.9.1 Theory-Driven PT Interventions

One of the major gaps is in the area of personalizing persuasive health applications based on culture and behavior change theories and evaluating them in the field. For example, very few behavior change interventions in the prior literature have been designed and evaluated based on theory. According to Michie et al. [63], "*even when people use theory, they tend to use it to explain behavior but not to change behavior*" (p. 663). Moreover, according to Orji [30], even PT interventions that claim to use theory "*are usually developed using determinants identified from the theories and from the literature without actually establishing the suitability of the determinants for the target group prior to PT design*" (p. 30) [30]. Although Orji [30], for example, adopted Michie et al.'s [63] framework in her dissertation, her focus was on the eating domain, the Health Belief Model and game design.

2.9.2 Effect of Culture on PT Interventions

The second major gap in the extant literature is that PT intervention research on the effect of culture, especially in field settings, is limited. Although Khaled [125] in her dissertation conducted research on the design of culture-tailored PTs, her focus was on smoking cessation. Moreover, apart from the PT intervention being a game, her target audience was the two dominant populations in New Zealand—the Europeans and the Maori people, which represented the individualist and collectivist cultures, respectively.

2.9.3 Understudied Populations in PT Research

The third major gap in the prior literature is that few to no PT intervention studies have been conducted on the African populations [22]. In particular, despite the widespread problem of physical inactivity [152], the African continent (including Nigeria the most populous country in Africa) has been overlooked in the area of PT interventions aimed at motivating behavior change.

This dissertation aims to bridge the identified gaps by employing a systematic approach grounded in theory and evidence-based culture-tailored PT design.

3 Research Methodology

This chapter focuses on the Design Science Research Methodology (DSRM) adopted by this dissertation, the EMVE-DeCK (Explain-Map-Validate-Explain-Design-Change-Knowledge) Framework for the design and evaluation of the proposed persuasive health application (PHA), the mixed-method approach and the types of statistical analysis carried out on the collected user data.

3.1 Design Science Research Methodology

The design of a persuasive technology (PT) intervention is a multi-stage process. Various methodologies for designing successful information systems have been proposed in the literature. However, my research adopted the DSRM, which is a commonly accepted framework for designing successful information systems aimed at behavior change [67]. It was proposed by Peffers [67]. Figure 3.1 shows the DSRM. It is a five-stage intervention design process, which alternates between specific stages directly involving the target users and the designer (gray-background stages) and those involving the designer only (white-background stages) [153]. It comprises the research problem identification, proposition of a solution, user study and modeling, system design and implementation, system demonstration, system evaluation and communication of findings.

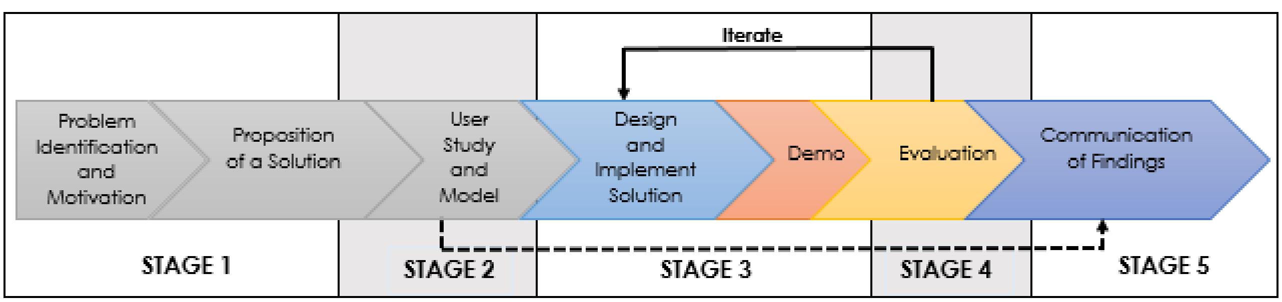

Figure 3.1: Design Science Research Methodology (adapted from [45][67][153])

3.1.1 Identification of Problem and Proposition of Solution (Stage 1)

This stage corresponds to the overarching research question (RQ0) presented in the introduction in Section 1.3. It comprises two phases: identification/definition of the research problem (along with the motivation) and the proposition of a solution.

Problem Identification and Definition

This phase of stage 1 entails identifying, defining and motivating the research problem through a literature review and writing a comprehensive report on it. It is discussed in detail in Section 1.1 and Section 1.2. Overall, the problem identification and definition is captured in the overarching research question which this dissertation attempts to answer: "*Given the global problem of inactivity and unsuccessful attempts to tackle it in the past, how and to what extent could persuasive technology, especially when addressing cultural factors, be utilized to promote physical activity?*" The benefit of answering this research question is four-fold and presented as follows:

1. Health: improve health and well-being through physical activity;

2. Economic: cut down cost spent on healthcare due to the treatment of non-communicable diseases;

3. Theoretical: provide a theory-based framework for designing and evaluating technology-based behavior change interventions; and

4. Technological: provide validated culture-specific PT design guidelines based on experimental evidence for the design and personalization of future PT health interventions in the health domain.

Proposition of a Research Solution

The second phase of stage 1 entails the research approach and steps taken to solve the research problem. The approach I took to solve the research problem is a multidisciplinary one, which I discussed in detail in Section 1.4. It encompasses the employment of Social Cognitive Theory (SCT—from Social Psychology), Technology Adoption Model (from Information Systems), Persuasive Technology and Personalization (from Human-Computer Interaction (HCI)) to address the physical-inactivity problem. Moreover, the steps taken to solve the problem, which encompass all of the four components of the multidisciplinary approach, are represented in the EMVE-DeCK Framework (see Section 3.2).

3.1.2 User Study and Modeling (Stage 2)

This stage focuses on the user studies aimed at modeling the target users and understanding their needs, behavioral determinants, social-cognitive-belief levels, persuasion profiles, Persuasive Technology Acceptance Model (PTAM) and Persuasive Technology Use Model (PTUM). It entails gathering empirical evidence, which will be used to inform the design of the proposed persuasive health intervention. Table 1.1 shows a description of the relevant user studies at a high level mapped onto their corresponding research questions. Moreover, Table 1.2 shows all of the investigations (in each study in Table 1.1) organized in chapters.

3.1.3 Design, Implementation and Demonstration of PHA (Stage 3)

This stage addresses the fourth research question of the dissertation (RQ4), "*How can we leverage the culture-specific empirical findings from the user studies in the design of an actual PHA tailored to the target audience?*" To answer this research question, I underwent the design and implementation of an actual PHA (a fitness application) in two phases. The first phase includes the design and implementation of the proposed PHA based on the culture-specific user models (S1), persuasion profiles (S2) and application-feature requirements (S3) uncovered in Stage 2. The second phase focuses on the in-house demonstration of the proper functioning of the application by the designer and pre-pilot testers. It entails testing the functionalities of the application to ensure it meets the user requirements and specifications and is free of bugs [153].

3.1.4 Evaluation of PT Health Intervention (Stage 4)

This stage entails the evaluation of the proposed PHA among the target users in the field. It is aimed to uncover the user experience (UX) design, overall and culture-tailoring effectiveness of the PHA. Specifically, this stage answers the fifth and sixth research questions of the dissertation and its subquestions.

The fifth research question (RQ5) this stage aims to answer is, "*How can we evaluate the UX design of an actual PHA prior to its usage in the field?*" Its subquestions include the following:

1. Does the UX design determinants of the *intention to use* a PHA (prototype) generalize to an actual application (evaluated in the field)?

2. Does the actual PHA meet the UX design requirements for its acceptance by the target audience?

Moreover, the sixth research question (RQ6) this stage aims to answer is, "*How can we evaluate the effectiveness of an actual PHA in changing behavior in the field?*" Its subquestions include the following:

1. Is the actual health application equipped with persuasive features more likely to be effective in motivating the physical-activity behavior of the target audience than the unequipped?

2. Is the tailored PHA more likely to be effective in motivating the physical-activity behavior of the target audience than the untailored?

3.1.5 Communication of Findings (Stage 5)

This stage entails publishing the empirical findings from the user studies in journals, conferences as well as this dissertation. The findings from some of the user studies presented in Table 1.2 have been previously published in journals and conferences, e.g., [27], [154], [155]. See the full list of my publications (p. iii).

3.2 EMVE-DeCK Framework

Figure 3.2 shows the EMVE-DeCK Framework. It is a systematic design process that lays out the multidisciplinary approach (Figure 1.1) to solve the research problem. Basically, it encapsulates the last four stages of the DSRM, which include user studies and models (steps 1-4), design and implementation of the proposed solution (step 5), demonstration and evaluation of the solution (step 6), and communication of findings (step 7). It is grounded in Bandura's [79] Triad of Reciprocal Determinism (TRD) shown in Figure 2.1, with "Environmental Factors" in the TRD mapped to "Technological Factors" in the EMVE-DeCK Framework.

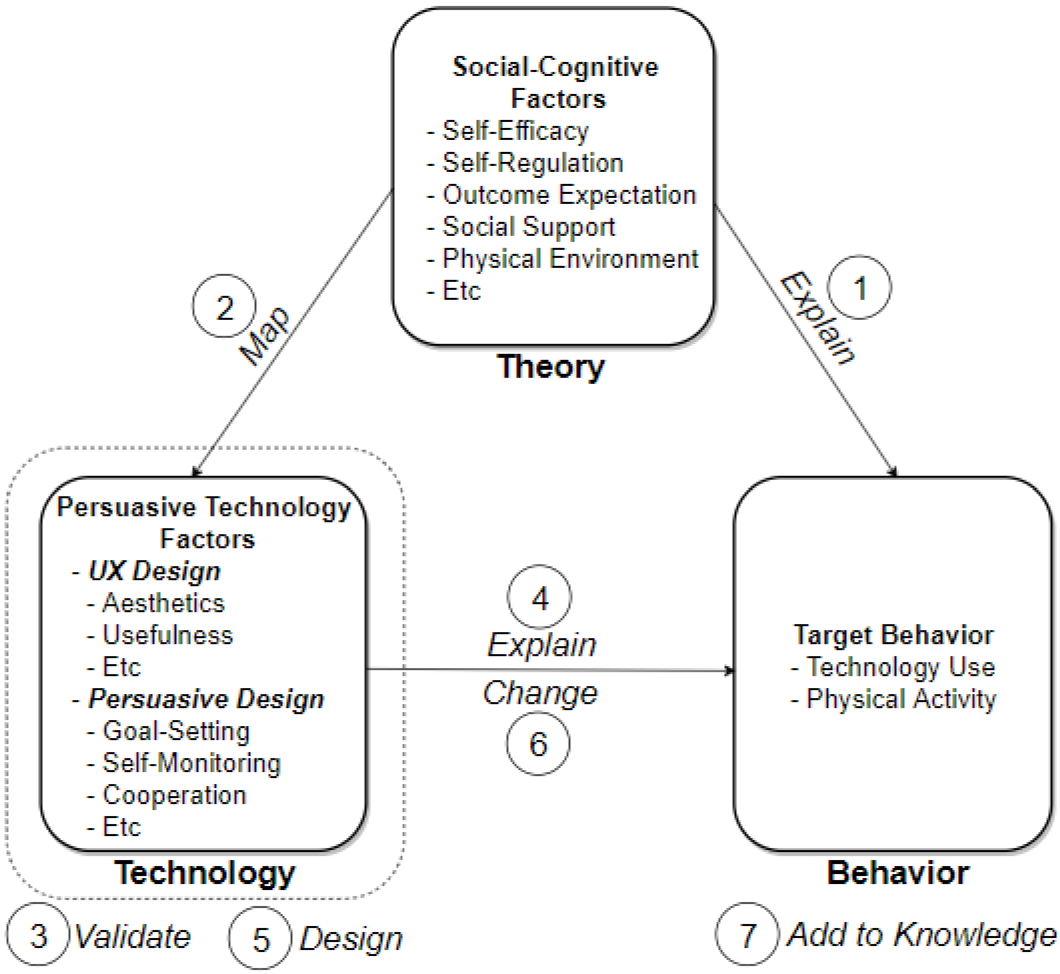

Figure 3.2: Theory-driven EMVE-DeCK Framework for designing and evaluating behavior change interventions (adapted from [79])

3.2.1 Justification of the EMVE-DeCK Framework

The EMVE-DeCK Framework builds on Michie et al.'s [63] three-step framework for designing theory-based interventions by including additional steps useful to PT design. Unlike the Michie et al.'s framework (Figure 2.9), the EMVE-DeCK Framework allows for the validation of theoretical determinants of behavior (mapped onto corresponding persuasive strategies) in the application domain. This step can be compared to the third phase of Oinas-Kukkonen and Harjumaa's [61] Persuasive System Design (PSD) framework (Figure 2.8), which has to do with *the selection of persuasive features to be implemented in the PT domain.* Specifically, in the EMVE-DeCK Framework, the third step allows the intervention designer to confirm theory-based findings and, due to limited resources, to select a subset of the validated persuasive strategies to implement in the proposed persuasive application. Second, unlike the Michie et al.'s framework, the EMVE-DeCK Framework includes a fourth step that investigates the design-related factors that explain the adoption of the proposed PT intervention. This step can be compared to the third step of the first phase of Oinas-Kukkonen and Harjumaa's PSD framework (Figure 2.8). The first phase is *understanding key issues behind persuasive contexts*, and its third step is *investigating the direct and indirect routes of persuasion*, which is equivalent to understanding the direct/indirect UX design attributes and persuasive design features that drive PT adoption. Overall, the EMVE-DeCK Framework can be viewed as an integration of Michie et al.'s [63] intervention design steps from the theory domain and Oinas-Kukkonen and Harjumaa's [61] PT design phases from the application domain using Bandura's [79] TRD. Particularly, it bridges the gaps in both existing frameworks: (1) the lack of validation of persuasive strategies and investigation of PT adoption in the application domain (Michie et al.'s framework), and (2) the lack of employment of theory-based persuasive strategies mapped to behavior determinants in the theory domain (Oinas-Kukkonen and Harjumaa's PSD framework).

3.2.2 Description of the Steps in the EMVE-DeCK Framework

The EMVE-DeCK Framework is a theory-driven framework for designing and evaluating PT-based behavior change interventions. It comprises seven steps, which are presented as follows:

1. **Explain:** Employ "Theory" to *explain* the performance of the target "Behavior" by uncovering the relationship between the "Behavioral Determinants" and the target "Behavior";

2. **Map:** *Map* the significant "Behavioral Determinants" in the "Theory" domain to "Persuasive Strategies" in the "Technology" domain;

3. **Validate:** *Validate* the target users' receptiveness to the "Persuasive Strategies" in the "Technology" domain;

4. **Explain:** Employ "Theory" to *explain* the adoption of the proposed persuasive "Technology" by uncovering the relationship between the UX/persuasive "Design Determinants" and the proposed "Technology Adoption";

5. **Design:** *Design* and implement theory-driven, tailored persuasive "Technology";

6. **Change:** Deploy "Technology" to *change* "Behavior" in the field; and

7. **Knowledge:** Contribute "Findings" to *Knowledge.*

The first step of the EMVE-DeCK framework (Explain: Employ "Theory" to *explain* the target "Behavior") and the second step (to *Map* the significant "Determinants" of behavior in the "Theory" domain to "Persuasive Strategies" in the "Technology" domain) can be mapped onto the three steps in Michie et al.'s framework (see Figure 2.9). The third step of the EMVE-DeCK framework entails the validation of the significant "Determinants" of behavior (mapped to "Persuasive Strategies" in the "Technology" domain) in the application domain. It is a form of triangulation of the behavioral determinants with users' persuasion profiles (i.e., their receptiveness to persuasive strategies) in order to determine which persuasive strategies are more likely to be effective in the application domain and thus should be implemented. It is worthy of note that this is one area the EMVE-DeCK framework mainly differs from Michie et al.'s framework. Validation of quantitative findings through triangulation has become important due to their receptiveness to a number of biases inherent in quantitative data research, e.g., measurement bias, sampling bias, procedural bias, etc. [156]. For this reasons, researchers and intervention designers are encouraged to tests the consistency of empirical findings by using different instruments in order to control for some of the human and non-human threats that might influence the empirical results negatively [157]. Moreover, the fourth step entails determining what UX design attributes of the PT will facilitate its adoption and use by the target audience. The fifth step entails implementing the validated persuasive strategies in the actual PT and evaluating their effectiveness in the application domain (e.g., in the field). Finally, the seventh step entails contributing all of the research findings in the previous steps to the body of knowledge through publication.

Putting it all together, the EMVE-DeCK Framework, in the context of *behavior change*, can be regarded as *the employment of "Theory" and "Technology" to **explain** and **change** behavior, respectively, by **mapping** behavior determinants in the "Theory" domain to corresponding persuasive strategies and **validating** them in the "Technology" domain.* Moreover, in the context of *technology adoption*, the EMVE-DeCK framework, can be regarded as *the employment of theoretical UX design attributes to **explain** and **drive** the adoption (acceptance and use) of the proposed "Technology" aimed at behavior change.* Although, the UX design attributes are encapsulated in the "Technology" domain, partly due to convenience, they could as well be situated in the "Theory" domain since the TAM is a theoretical model of technology acceptance.

3.2.3 Situation of User Studies in the EMVE-DeCK Framework

As a proof of concept, all of the user studies carried out in this dissertation are situated in the EMVE-DeCK Framework. Specifically, the framework helps us to visualize and understand how the various user studies in the dissertation, which cut across theory (the SCT) and technology (the PHA), fit together. Although most of the steps in the EMVE-DeCK Framework derive from the DSRM, seeing how all of the user studies are connected, through the TRD lens, cannot be achieved with the DSRM framework alone. Finally, although the TRD has been adopted and adapted extensively in PT research, prior studies (e.g., [32], [158], [159]) have not been able to frame it in terms of relevant interconnected user studies the way the EMVE-DeCK Framework does. Aside from looking at the TRD from the point of view of using theory and technology to change behavior, the EMVE-DeCK Framework establishes a clear link between the TRD and the three middle stages of the DSRM (user studies, PT design and evaluation). Hence, with the aid of the EMVE-DeCK Framework, researchers interested in using the TRD as an underlying framework are able to: (1) see its augmented view in the context of PT, and (2) situate their user studies for designing and evaluating their PT interventions accordingly.

3.3 Data Collection and Analysis

In this section, I focus on the research design adopted by the dissertation, the software tools and online platforms employed in collecting empirical data from study participants, and the data analytic tools used in carrying out statistical and thematic analyses.

3.3.1 Research Design

In this dissertation, I adopted a mixed-method approach in the collection of empirical and experimental data to answer the research questions and test my research hypotheses. A mixed-method research design is "*an emergent methodology of research that advances the systematic integration, or 'mixing,' of quantitative and qualitative data within a single investigation or sustained program of inquiry*" (p. 1) [69]. According to Smith [69], the mixed-method research design began in the social sciences and moved to other domains such as the Health Sciences [160] and HCI [161] over time. Examples of studies in the HCI and PT domains include [32], [162], [163], etc. In the design of data-driven systems, the mixed method is encouraged to ensure that the designers gather comprehensive and cross-verifiable empirical data (quantitative and qualitative) to inform their design. In my quantitative studies, I employed a close-ended Likert scale (e.g., from "Strongly Disagree - 1" to "Strongly Agree - 7") in measuring the empirical constructs of interest (e.g., *perceived aesthetics*). On the other hand, I employed open-ended questions to collect qualitative data (in the form of comments and feedback) from participants. Specifically, qualitative data allows researchers to gain useful insights into the multiple perspectives on a single issue from the individual lenses of the study participants [69][160]. Finally, to investigate whether my initial empirical findings at the level of perception generalize to an experimental setting, I conducted a four-week pilot study to evaluate the effectiveness of an actual PHA in the field.

3.3.2 UX Research

Application prototypes (e.g., [162], [164], [165]) and storyboards (e.g., [33], [166], [167]) are being used to obtain quantitative as well as qualitative data from participants in UX and PT studies. For example, to obtain rich qualitative data from the study participants in S2, I presented a screenshot of a PHA prototype and storyboards to the participants and asked them to provide their thoughts and opinions based on their first impression. Regarding the PHA prototype, I requested the participants to "*please enter here [textbox] one key feature you would expect the app to have if you were to use it.*" Moreover, in the second part of the study, in which persuasive features are illustrated on storyboards, I requested the participants to "*provide comments about this application feature [persuasive strategy illustrated on the storyboard] to justify your rating here [textbox].*" Basically, storyboards serve as a common visual language that different participants from different backgrounds can easily make sense of. They are commonly employed in UX and PT research to elicit insightful responses from potential users of a proposed application. They have been successfully employed in a number of studies in the existing literature [33][62] to uncover useful guidelines for designing PHAs aimed at motivating behavior change.

3.3.3 Data Collection Platforms

To collect the empirical data for the dissertation, I used online data-collection platforms such as Google Forms , Survey Monkey and Fluid Survey. Google Forms is a free survey administration application provided by Google as part of G Suite comprising several applications such as Google Docs and Google Sheets. On the other hand, Survey Monkey and Fluid Survey are commercial survey administration platforms. Fluid Survey has now been acquired by Survey Monkey. All three platforms allow researchers to create quantitative and qualitative surveys and invite participants to take part via email or a Universal Resource Locator (URL)/link. Aside from supporting texts (closed- and open-ended questions), the three platforms allow researchers to upload images and videos as well. Examples of images include screenshots of persuasive application prototypes and storyboards. Moreover, examples of videos include behavior models demonstrating to the participants how to correctly perform a given bodyweight exercise (e.g., squat) [32]. To increase the reliability of collected data, among other things, all three platforms allow researchers to randomize the order of questions and their answer options, validate participants' responses and ensure that a participant only responds once.

3.3.4 Recruitment of Participants

To recruit participants for the user studies presented in this dissertation, I employed Amazon Mechanical Turk (MTurk) [70], Facebook, LinkedIn, email, the University of Saskatchewan's announcement portal and paper-based surveys. After the studies had been approved by the University of Saskatchewan Research Ethics Board, they were posted on one or more of the recruitment platforms for anonymous participation. MTurk supports the collection of quality data through: (1) the integration of a quality-assurance mechanism based on a reward-and-punishment system, and (2) a wide reach of diverse participants cutting across different demographics and geographical locations [70]. Specifically, the MTurk platform allows researchers to specify certain demographic requirements for potential participants (e.g., country of origin, gender, age, location, etc.). For the most part, I used the MTurk platform to recruit individualist participants (Canadians and Americans who were resident in Canada and the United States). On the other hand, I used email, social media and in-person paper-based questionnaires to recruit most of the collectivist participants (Nigerians who were resident in Nigeria). Unlike Canadians and Americans, very few Nigerians were on the MTurk platform. This is one of the reasons I used email, social media and paper-based questionnaires to collect data from among the Nigerian population. In appreciation of participants' time spent in completing the surveys, they were compensated with a token amount, gift card or phone-credit card.

3.3.5 Data Analysis

Given that the dissertation adopted a mixed-method research design, two major types of data analysis were carried out. I provide an overview of the two types of data analysis (quantitative and qualitative), the method employed for their synthesis (triangulation), and the tools used for the statistical analysis.

Quantitative Data Analysis

The study of PTs from a quantitative standpoint (e.g., through surveys and experiments) helps researchers to test hypotheses and reach conclusions that are supported by statistical evidence [168]. To analyze the quantitative data gathered from the user studies, I employed two techniques: Structural Equation Modeling (SEM) [72] and Analysis of Variance (ANOVA) [169].

Structural Equation Modeling. SEM is a multivariate statistical technique that is employed to investigate the structural relationships between empirical constructs also known as latent variables. The empirical constructs are indirectly measured using a set of observable items (questions) called indicators. Basically, there are two types of indicators: *reflective* and *formative*. Reflective indicators are considered to be caused by the latent variable they measure, while formative indicators are considered to be the cause of the latent variable they measure. Specifically, reflective indicators are regarded as equivalent and interchangeable, meaning each of the indicators is a repeat of the other [72][170]. In this dissertation, reflective indicators are used in measuring the different constructs in the path models presented.

Using a combination of factor analysis and multiple regression analysis, SEM sets out to validate a theoretically driven model. Examples of SEM analyses include Path Analysis, Covariance-Based Structural Equation Modeling (CBSEM) and Partial Least Squares Structural Equation Modeling (PLSSEM), also known as Partial Least Squares Path Modeling (PLSPM). PLSPM is a soft-modeling-technique that serves as an alternative method to CBSEM, which requires rigid distributional assumptions on its data. Unlike CBSEM, PLSPM requires less strict distributional assumptions on its data [72][74]. Hence, PLSPM is the PLS-based approach to CBSEM, employed to study "*complex multivariate relationships among observed and latent variables.*" (p. 3) [74]. With the aid of a path diagram or path model, PLSPM allows complex relationships to be "*presented in a convenient and powerful way to others not familiar with SEM*" (p. 1) [73]. The relationship that exists between two construct is quantified by a statistical metric called path coefficient (β), which usually ranges from 0 to 1. Relationships with β values less than 0.2 are often regarded as weak, while those equal or greater than 0.2 are regarded as strong [171]. Moreover, PLSPM shows how a number of constructs, individually or in combination, explain the variance of another construct in the path model. The term, coefficient of determination (R^2), is used to describe the amount of variance of a particular construct explained by other constructs. Finally, PLSPM supports a multigroup analysis, which is used to uncover how two different groups significantly differ with respect to certain relationships in a path model.

In my data analysis, I used the "plspm" package (a library in the R programming language) to carry out the PLSPM in this dissertation [74]. Moreover, I used R Studio (an open-source data-analytic tool) for my path modeling. Finally, in the presentation of the PLSPM results, "draw.io," an online drawing tool, was used in creating the path models of the interrelationships among the empirical constructs in each investigation.

Analysis of Variance. ANOVA is a statistical analysis that allows researchers to uncover how two or more groups significantly differ in terms of the overall mean ratings of certain constructs (e.g., perceived self-efficacy, *perceived aesthetics*, goal-setting persuasive feature, physical activity level, etc.). In the various user studies presented in this dissertation, I began the ANOVA by computing and plotting the average ratings of the constructs of interest for the two cultural groups to determine their performance levels or scores. The "ggplot2" package in R was used in creating most of the graphical plots in the dissertation. Moreover, the ARTool package [76] was used in carrying out ANOVAs to uncover the differences that exist between/among group means, the main effect of and/or interaction between certain factors. Specifically, the ARTool employs the Aligned Rank Transform (ART) for performing non-parametric factorial analyses using only ANOVA procedures after data alignment and ranking [75]. According to [75], "*The ART relies on a preprocessing step that 'aligns' data before applying averaged ranks, after which point common ANOVA procedures can be used, making the ART accessible to anyone familiar with the F-test*" (p. 143). The ARTool is used instead of the Statistical Package for the Social Sciences (SPSS) [172] to conduct non-parametric analyses because most questionnaire-based data (such as those I collected) do not meet the normal distributional assumptions required to carry out parametric analyses using SPSS [119].

In ANOVA, two types of effects are looked at: *main* and *interaction*. Main effect assesses the effect of a dependent variable on an independent variable. Examples of dependent and independent variable are gender and physical activity, respectively. Moreover, interaction effect assesses the effect of a third variable on the relationship between an independent and a dependent variable. An example of a third variable that may influence the relationship between gender and physical activity is age. For example, for younger people, males and females may significantly differ in their physical activity level, e.g., males being more active than females. However, for older people, both genders may not significantly differ. Based on this result, we say there is an interaction effect of age on the relationship between gender and physical activity.

Qualitative Data Analysis

The study of PTs from a qualitative standpoint can provide useful insights that the quantitative approach cannot offer. Three key benefits of the qualitative approach include: (1) uncovering rich insight into a particular persuasive applications, including its strengths and weaknesses, (2) gathering useful insight into a particular user group (e.g., the target group's preferences, biases and reactions), and (2) creating hypotheses that will serve as a basis for future research efforts [168]. To analyze the qualitative data in this dissertation, I adopted the "thematic analysis" method. Thematic analysis is "*a systematic method of breaking down and organizing rich data from qualitative research by tagging individual observations and quotations with appropriate codes, to facilitate the discovery of significant themes*" [77]. Specifically, a theme is a summary description of users' belief, thought, perception or need that is discovered from their qualitative attitudinal and behavioral data in a given user study. It emerges when related ideas are found multiple times across several participants. I employed the thematic analysis to identify the main themes in the qualitative data obtained from the UX studies (e.g., comments provided by participants on storyboards) [77][173].

Triangulation

Triangulation, in the context of HCI research, is the act of combining more than one research method to study one problem. Hence, it is defined as "*an attempt to map out, or explain more fully, the richness and complexity of human behavior by studying it from more than one standpoint*" [156]. Carvalho and White [174] put forward four reasons for carrying out triangulation: (1) confirming or refuting quantitative results using the qualitative approach; (2) enriching quantitative results by using the qualitative approach to uncover information on variables and constructs not obtained by quantitative surveys; (3) generating research hypotheses from qualitative analysis, which are going to be tested through the quantitative approach; and (4) explaining quantitative results using qualitative results and vice versa.

In UX and PT research, triangulation has become important because of the various types of bias encountered in user studies (especially in quantitative research), e.g., measurement bias, sampling bias, procedural bias, etc. [156]. According to Kennedy [156], using either quantitative or qualitative research design "*can be incredibly useful for giving insight into a particular aspect of what you're studying, but relying solely on one is a big mistake*" due to the different types of biases. To reduce these types of bias, triangulation "*tests the consistency of findings obtained through different instruments and increases the chance to control, or at least assess, some of the threats or multiple causes influencing our results*" [157]. Hence, to increase the consistency and reliability of research findings, at the end of a mixed-method research analysis, there is a need to foster convergence between the quantitative and qualitative findings by way of triangulation [175].

In this dissertation, I employed methodological triangulation to cross-verify and synthesize the findings from the quantitative and qualitative analyses. This step in data analysis helps to consolidate the overall finding in a given user study through the cross-verification of two results from two different types of analysis.

4 Theoretical Determinants of Behavior

This chapter focuses on the first two steps of the EMVE-DeCK Framework, which are the first user study of this dissertation. The study (S1) entails understanding the target populations and their theoretical models of behavior change. S1, which comprises two investigations (S1a and S2b), is situated in the EMVE-DeCK Framework as shown in Figure 4.1. It is based on the Social Cognitive Theory (SCT) of behavior change, which is one of the most popular behavior models for designing health interventions.

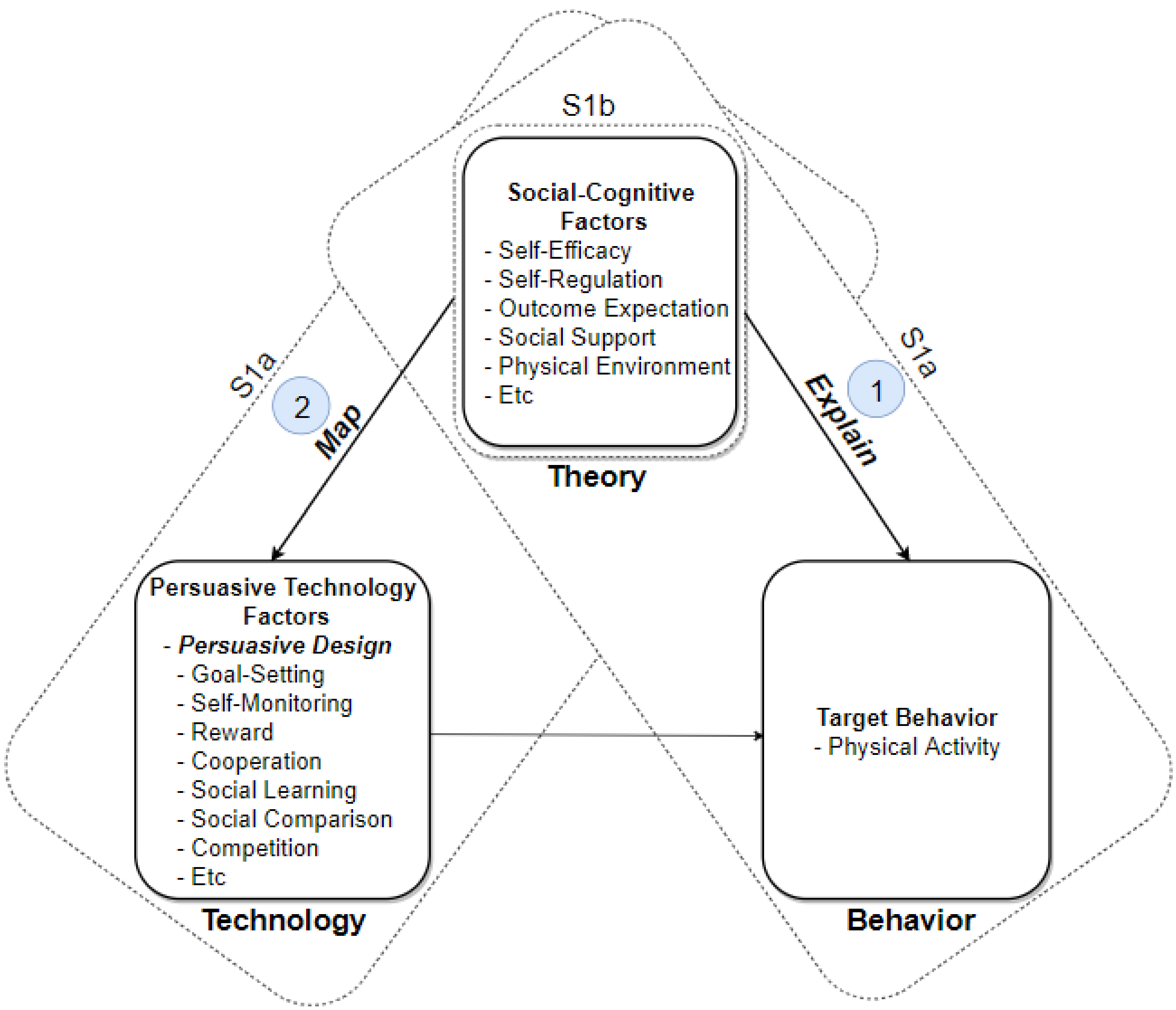

Figure 4.1: Situating the theoretical determinants of behavior change in the EMVE-DeCK Framework

The first investigation (S1a[1]) examines the social-cognitive model of the physical-activity behavior of the target audience and the moderating effect of culture. Specifically, it uncovers the culture-specific social-cognitive determinants of physical activity and their mapping to persuasive strategies in the application (technology) domain. The second investigation (S1b) examines the social-cognitive-beliefs profile and the physical activity level of the target audience and the moderating effect of culture. Finally, the chapter synthesizes the findings from S1a and S1b and provide culture-specific persuasive technology (PT) design guidelines for implementing a culture-tailored persuasive health application (PHA) in the application domain.

4.1 Motivation

Research [25][63][176] shows that health interventions which are informed by theory are more likely to be successful compared with those that are uninformed. As a result, attempts have been made in the literature to use various behavior change theories such as SCT [22], Health Belief Model [31], Self-Determination Theory [177], etc., to explain the behavior of different target groups. Of these behavior change theories, the SCT is one of the most popular and commonly employed in health promotion [89][92][159]. This is the main reason I chose the SCT as the theoretical framework for understanding the physical-activity behavior of the target audience. However, most of the SCT-based studies have been aimed at explaining the behaviors of various target groups alone. In the PT domain, there is limited work on employing it all the way from explaining behavior to informing the design, implementation and evaluation of technology-based interventions. In this dissertation, I do not only aim to use the SCT to explain behavior, I aim to use it as a theoretical framework for designing and evaluating a PHA as shown in the EMVE-DeCK Framework.

4.2 Related Work

In this section, I provide a review of the relevant SCT-based studies that have been carried out in the physical-activity domain. Rovniak et al. [94] conducted a study to model thee physical-activity behavior of 277 university students from Virginia Polytechnic Institute and State University in the United Sates using the SCT. Their social-cognitive model explained 55% of the variance of Physical Activity. They found that Self-Efficacy had the strongest total effect on Physical Activity, followed by Self-Regulation and Social Support. However, they found that Outcome Expectation had no significant direct or total effect on Physical Activity when Self-Efficacy was controlled for in the social-cognitive model. Similarly, Anderson et al. [89] modeled the physical activity of 999 adults from 14 Southwestern Virginia churches in the United States. Their model explained 46% of the variance of Physical Activity. Self-Regulation had the strongest effect on Physical Activity. It mediated the effect of Self-Efficacy on Physical Activity. Moreover, the effect of Social Support on Physical Activity was mediated by Self-Efficacy and Self-Regulation. Resnick [178] modeled the

[1]This investigation and its findings have been published before [27]. Most of it is reproduced verbatim in this dissertation.

physical-activity behavior of 201 older adults in the United States, who were living in a continuing care retirement center. Their model accounted for 40% of the variance of Current Exercise, with Self-Efficacy, Outcome Expectation and Prior Exercise directly influencing Current Exercise. Finally, Haider and Sharma [179] modeled the physical activity of 58 South Asian college students in the United States. Their model explained for 8.2% of Exercise Behavior, with only Self-Efficacy having a direct effect on Exercise Behavior.

4.3 Gaps in Prior Work

Behavior theories, in general, and the SCT, in particular, have been mostly employed to explain behavior in Western population, followed by the Asian population [22][92]. In the context of physical activity, there is little to no research on the social-cognitive model of the African population. Thus, the current study is aimed to fill this gap. Secondly, it aims to uncover how a collectivist culture (on the African continent) and an individualist culture (on the North American continent) differ in their social-cognitive models of physical-activity behavior. Thirdly, it aims to triangulate the findings from S1a (significant behavior determinants) with those from S1b (social-cognitive-beliefs levels) to understand the most important social-cognitive determinants in each culture that the PT intervention should prioritize. This kind of study, based on triangulation, is scarce in the existing literature on technology-based health interventions. It is mainly employed in the marketing domain to understand what sales-related constructs companies should target to increase profitability [72]. Finally, my current study will not stop at explaining behavior, it will serve as a theoretical basis for further studies in the application (technology) domain and comparisons of findings in the theory and application domains.

4.4 Study Objective

Due to the gaps in the existing literature, the main objective of S1 is to answer the first research question of the dissertation (RQ1), "***How can behavior change theory be employed to inform a PT intervention to promote physical activity?***" This research question is broken down into the following three subquestions:

RQ1a. What are the theoretical determinants of the physical-activity behavior of the two target cultures?

RQ1b. How can the theoretical determinants be operationalized in the application (technology) domain?

RQ1c. What are the performance levels of the theoretical determinants in the two target cultures?

4.5 Study Method

To answer the above research questions, I conducted a quantitative study based on self-report. The study was based on six social-cognitive constructs: Physical Environment, Social Support Self-Efficacy, Self-Regulation, Outcome Expectation and Physical Activity. The user study was submitted to the University of Saskatchewan Behavioral Research Ethics Board for review. After approval, I recruited study participants from a Canadian university and a Nigerian university. In Canada, the questionnaire administration was online-based, while, in Nigeria, it was paper-based. It was paper-based in Nigeria because access to the Internet as at the time of the study in 2014 was challenging due to limited bandwidth, poor services and high pricing [180]. In Canada, the study was posted on the website of the Canadian university used as a case study. Interested students were requested (see consent form in Figure A.1) to answer the questionnaire, which took about 15 to 20 minutes, anonymously. They were given a chance to win CAD $50 as a compensation for their time. However, in Nigeria, the study was conducted in a classroom setting. It took about 15 to 30 minutes. Research assistants, resident in Nigeria, helped in administering the questionnaires to the study participants, after which the data was digitized using Microsoft Excel. Unlike the participants in Canada, each of the Nigerian participants was compensated with a N100 Nigerian phone-credit card.

4.5.1 Measurement Instruments

The survey questionnaire was based on existing instruments in the literature, which had been validated in different empirical studies [94][181][182][183]. The instruments (scales) measured all six constructs of interest—Self-Efficacy, Self-Regulation, Outcome Expectation, Social Support and Physical Environment and Physical Activity—at the level of perception. For brevity, I have omitted the qualifier "perceived" when referring to each of the six constructs. For the most part, instead of saying "Perceived Self-Efficacy," for example, I will simply refer to it as "Self-Efficacy." All of the constructs, apart from Physical Activity (measured on a numerical scale), were measured using an ordinal (Likert) scale. Some of the constructs such as Self-Efficacy are unidimensional (i.e., measured directly by their indicators), while others such as Self-Regulation are multi-dimensional (i.e., measured indirectly by using lower-order constructs (LOCs)).

Table A.1 (in Appendix A) shows all of the six SCT constructs, their LOCs and indicators (items). Physical Environment [184] and Self-Efficacy [182] were directly measured by their indicators, while Self-Regulation [94] and Outcome Expectation [183] and Support [181] were indirectly measured by their indicators through their LOCs. For example, Outcome Expectation was indirectly measured using the Self-Evaluative Outcome Expectation, Physical Outcome Expectation and Social Outcome Expectation LOCs, Self-Regulation was indirectly measured using the Exercise Goal Setting and Exercise Planning and Schedule LOCs, and Social Support was indirectly measured using the Family and Friends LOCs. Specifically, Physical Activity construct was directly measured using three numerical indicators: light-intensity activities, moderate-intensity activities and vigorous-intensity activities. Each of the three categories of activity measures the frequency and duration of engagement in activities that fall under that category over a week period (precisely the last seven days). Each of the types of activity is measured in MET-mins/week. The acronym, MET, represents "Metabolic Equivalent of Task." A physiological measure of physical activity, one MET (1 MET) is defined as the ratio of the rate of energy expended while a person is performing a certain physical activity to the rate of energy expended while s/he is at rest [5]. Specifically, 1 MET is equivalent to 1 kcal / (kg x hr). Different activities have different MET values or coefficients.

In the SCT-based questionnaire, Physical Activity (the target construct) was measured using all three types of activity. Table A.1 for the items measuring each of the three types of activities. Specifically, in the questionnaire, light-intensity activity was measured using walking. Each of these types of activity has MET values that are greater than 1: walking (MET value = 3.3), moderate-intensity activity (MET value = 4.0) and vigorous intensity activity (MET value = 8.0) [7]. Specifically, I adopted the validated International Physical Activity Questionnaire (IPAQ) measurement instrument [7][185] , which measures all three types of activities within the last seven days. The repeatability's Spearman's rho-value of the IPAQ instrument for the sum of all three activities (i.e., total MET-mins/week) is about 0.75. To calculate the MET-mins/week for each activity type, I used Equation 4.1. Specifically, "MET" represents the MET value of the activity type; (2) mins/day represents the amount of time spent in performing this type of activity per day; and (3) days/week represents the number of days per week for which this type of activity is performed. In calculating the MET-mins/week for each of the three types of activity, for walking specifically, missing (zero) values were replaced with the respective averages in each culture-based group. However, for the moderate- and vigorous-intensity activities, given that it was possible for participants to have not engaged in these types of activities in the last one week as reported due to their relative difficulty, missing (zero) values were not replaced with the respective culture-based average values [27].

$$MET - mins/week = MET \times \frac{mins}{day} \times \frac{days}{week} \tag{4.1}$$

Table 4.1: Demographics of participants in the social-cognitive determinants of physical activity study. COL = Collectivist culture, IND = Individualist culture.

		Number		**Percent**	
Criterion	**Subgroup**	**COL**	**IND**	**COL**	**IND**
Gender	Female	94	92	32.2	65.7
	Male	187	47	64.0	33.6
	Unspecified	11	1	3.8	0.7
Age	18-24	248	86	84.9	61.4
	25-34	26	41	8.91	29.3
	35-44	0	9	0.0	6.4
	45+	0	4	0.0	2.8
	Unspecified	18	0	6.2	0.0
Education	Technical/Trade School	7	7.0	2.4	5.0
	High School	204	66	69.9	47.1
	Bachelor	47	43	16.1	30.7
	Postgraduate	4	22	1.4	15.7
	Others	30	2	10.3	1.4

4.5.2 Participants

Table 4.1 shows the demographics of the study participants in each culture. About 220 subjects from different countries of origin participated from Canada, while about 300 participated from Nigeria. However, after filtering out the non-Canadians from the individualist sample, 140 Canadians, whose country of origin and residence was Canada, were left for data analysis. For the Nigerian group, all of the participants originated from and were residents of Nigeria. After cleaning, 292 participants were left for the data analysis.

4.6 S1a: Investigation of the Social-Cognitive Determinants of the Physical Activity of the Target Audience and the Moderating Effect of Culture

In this section and investigation (S1a), I present the research model, data analysis, results and discussion with regard to the following two the following subquestions which derive from RQ1.

RQ1a. What are the theoretical determinants of the physical activity of the two target cultures?

RQ1b. How can the theoretical determinants be operationalized in the application (technology) domain?

Thus, this investigation is aimed at: (1) uncovering the significant social-cognitive determinants of the physical-activity behavior of the target audience and the moderating effect of culture; and (2) mapping the significant social-cognitive determinants of physical activity in each culture to persuasive strategies in the application (technology) domain. Specifically, it deals with the first two steps of the EMVE-DeCK Framework: Explaining and Mapping. I begin the analysis with the first step, which is situated in the framework as shown in Figure 4.1. After uncovering the significant social-cognitive determinants of physical activity in the theory domain in each culture, I map them to persuasive strategies in the application (technology) domain.

4.6.1 Research Model

Due to the paucity of cross-cultural research in this area, I adopted an exploratory approach to investigate the social-cognitive model of physical activity in each culture using the research model shown in Figure 4.2. The exploratory research model shows the theoretical interrelationships (E1-E15) among the six social-cognitive constructs.

4.6.2 Data Analysis

I employed PLSPM to determine which of the relationships in the exploratory model is significant in each culture. Secondly, I employed a multigroup analysis to uncover how the two cultures significantly differ.

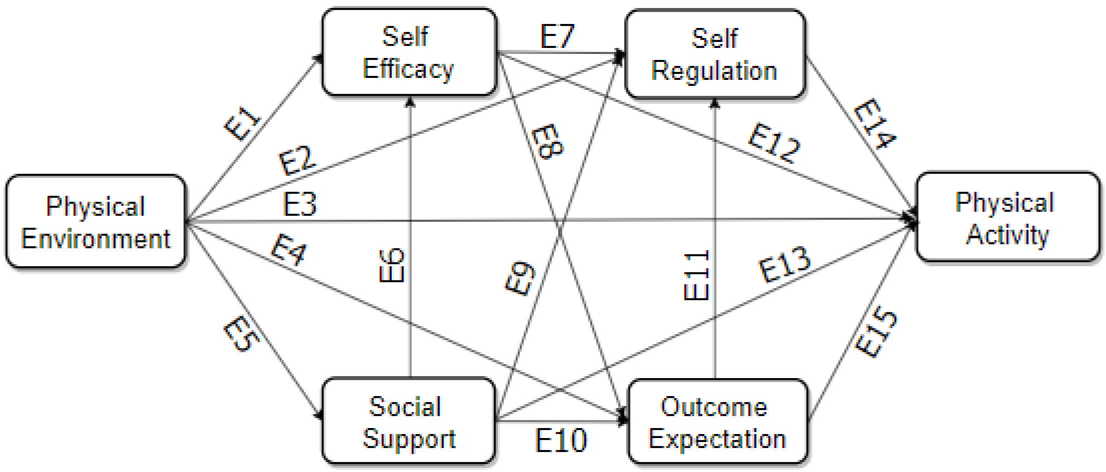

Figure 4.2: Exploratory social-cognitive model of physical-activity behavior

Evaluation of the Measurement Models

Prior to building and analyzing the culture-specific structural models, I evaluated their respective measurement models to ensure that the preconditions (the criteria for evaluating the structural models) were met [74][170]. The criteria include indicator reliability, internal consistency reliability, convergent validity and discriminant validity. Their definitions and the overall results of the evaluation are shown in Table 4.2. Most of these criteria were met. Specifically, the indicator reliability (based on the outer-loading metric) of each construct's item is presented in detail in Table A.1 in Appendix A. Some of the items were dropped from the respective models because of poor loading on their constructs as shown in Table A.1.

Table 4.2: Evaluation of the measurement models in the social-cognitive determinants of physical activity study [74][170][186]

Criterion	Definition of Criterion	Evaluation Result
Indicator Reliability	It is the degree to which an indicator that measures a construct is reliable. Thus, it is defined as the variance of the indicator that is not accounted for by measurement error.	Most of the outer loadings (see Table A.1) are greater than 0.7, except for a few, which are still included given that they are greater than 0.4 [170].
Internal Consistency Reliability	It is a measure of the extent to which a set of indicators that measure a construct produces similar scores.	The Dillon-Goldstein metric (DG.rho) for each construct in the respective measurement models was greater than 0.7.
Convergent Validity	It is a measure of how well the indicatores that measure a given construct are closely related.	The Average Variance Extracted for each construct was greater than 0.5, except for that of *Self-Efficacy* in the *Physical Environment* in the individualist model (0.30).
Discriminant Validity	It is a measure of the extent to which the indicators that measure a given construct are unrelated to another construct in the measurement model.	The crossloading criterion for each construct was used and no indicator loaded higher on any other construct than the one it was designed to measure.

Structural Analysis of Collectivist Model

Figure 4.3 shows the parsimonious social-cognitive model for the collectivist culture. The GOF is 49%, which is large and indicates the collectivist model fits its data well [187]. Moreover, the R^2 of the model is 12%, which is considered low in PLSPM.[2] In the collectivist model, Social Support ($\beta = 0.19$, $p < 0.001$) and Outcome Expectation ($\beta = 0.15$, $p < 0.001$) turn out to have the strongest significant direct effects on Physical Activity. Both of these social-cognitive constructs account for most of the variance (12%) of Physical Activity. However, Physical Environment, Self-Efficacy and Self-Regulation have non-significant direct effects on Physical Activity. Overall, the direct effect of Social Support on Self-Regulation ($\beta = 0.39$, $p < 0.001$) turns out to be the strongest among the interrelationships in the collectivist model.

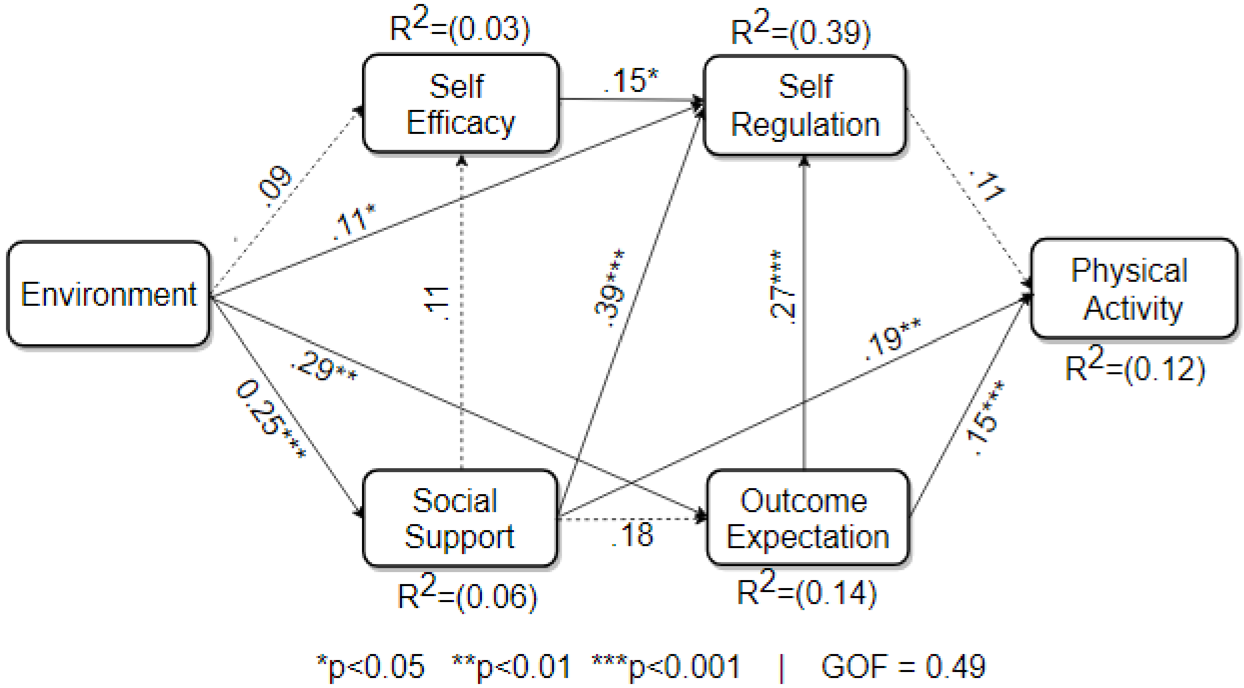

Figure 4.3: Collectivist social-cognitive model of physical-activity behavior (relationship unshown is a non-significant path coefficient, thus excluded when the model was built)

Structural Analysis of Individualist Model

Figure 4.4 shows the parsimonious social-cognitive model for the individualist culture. The GOF is 59%, which is large. Moreover, the R^2 value is 45%, which is moderate [74]. Particularly, Self-Efficacy ($\beta = 0.53$, $p < 0.001$) and Self-Regulation ($\beta = 0.21$, $p < 0.001$) have the strongest direct effect on Physical Activity. Both constructs account for 45% of the variance of Physical Activity. However, Physical Environment, Social Support and Outcome Expectation have non-significant direct effects on Physical Activity. Overall, the direct effect of Self-Efficacy on Self-Regulation ($\beta = 0.56$, $p < 0.001$) turns out to be the strongest relationship.

[2] GOF values of 0.10, 0.25 and 0.36 indicate the overall validation of the model is small, medium and large, respectively [187]. Moreover, R^2 values less than 0.3, between 0.3 and 0.6 and above 0.6 are termed low, moderate and high, respectively [74].

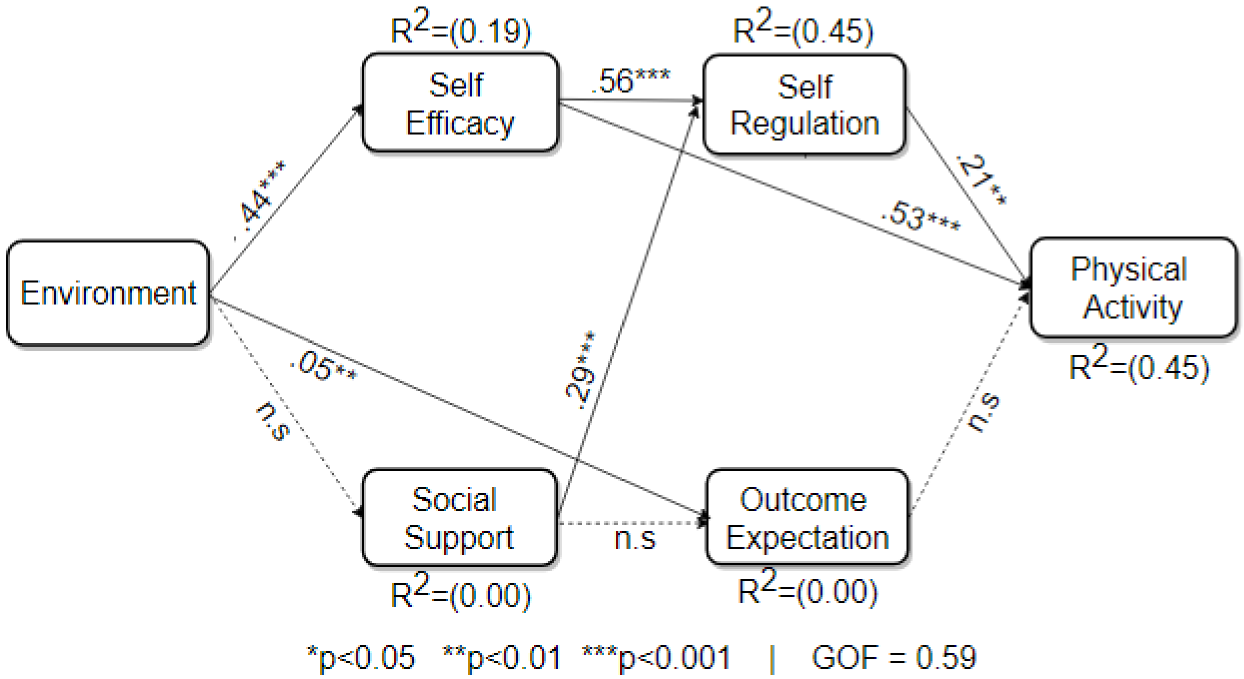

Figure 4.4: Individualist social-cognitive model of physical-activity behavior (relationship unshown or labeled "n.s" is a non-significant path coefficient, thus excluded when the model was built)

Effect Size and Cultural Difference

To uncover the magnitude of the effect of the exogenous constructs on Physical Activity and the cultural difference, I conducted an effect-size analysis. The effect size (f^2) is calculated using Equation 4.2 [72]. Unlike the significance test which indicates how confident we are that there is a relationship between two constructs, the effect size provides a measure of the magnitude or strength of the relationship. Table 4.3 shows the results of the analysis. In the individualist model, Self-Efficacy ($f^2 = 0.35$) and Self-Regulation ($f^2 = 0.02$) have a large and small effect size on Physical Activity, respectively. However, in the collectivist model, Social Support ($f^2 = 0.03$) and Outcome Expectation ($f^2 = 0.02$) have a small effect size.

$$f^2 = \frac{R^2_{inc} - R^2_{exc}}{1 - R^2_{inc}} \tag{4.2}$$

Table 4.3: Effect size of SCT constructs on physical activity. $f^2 = 0.02$: small, $f^2 = 0.15$: medium, $f^2 = 0.35$: large [72]. R^2_{inc} and R^2_{exc} are the coefficients of determination when the SCT construct is included and excluded from the SCT model, respectively. The bold effect size is large. "-" means no effect size as a result of SCT construct not having a significant effect on Physical Activity.

	COL			**IND**		
SCT Construct	R^2_{inc}	R^2_{exc}	f^2	R^2_{inc}	R^2_{exc}	f^2
Self-Efficacy (SE)	0.12	-	-	0.45	0.26	**0.35**
Self-Regulation (SR)	0.12	-	-	0.45	0.44	0.02
Outcome Expectation (OE)	0.12	0.10	0.02	0.45	-	-
Social Support (SS)	0.12	0.09	0.03	0.45	-	-
Physical Environment (ENV)	0.12	-	-	0.45	-	-

Multigroup Analysis

The relatively higher R^2, GOF and β values in the individualist model than their counterparts in the collectivist model is an indication that culture is a moderating factor in the exploratory model shown in Figure 4.2. Hence, I conducted a multigroup analysis based on all of the relationships in the culture-specific models. The analysis, which was based on 1000 bootstrap samples, is aimed at determining the relationships in which the two cultural groups significantly differ. The result (Table 4.4) showed that there are some significant differences between the individualist and collectivist groups with respect to seven of the relationships. For example, the relationship between Self-Efficacy and Self-Regulation and that between Self-Efficacy and Physical activity are significantly stronger in the individualist model than in the collectivist model ($p < 0.05$). Similarly, the relationship between Physical Environment and Self-Efficacy and that between Self-Regulation and Physical Activity are significantly stronger in the individualist model than in the collectivist model ($p < 0.05$). However, the relationship between Social Support and Physical Activity is marginally stronger in the collectivist model than in the individualist model ($p = 0.078$). I discuss the implications of these significant differences in the discussion section.

Table 4.4: Multigroup analysis showing the significant differences between collectivist and individualist cultures in the SCT model of physical activity. SE = Self-Efficacy, SR = Self-Regulation, ENV = Physical Environment, SS = Social Support, OE = Outcome Expectation, -/n.s = non-significant.

Path	**COL**	**IND**	***p*-Value**	**Sig**	**Remark on Cultural Difference**
SE $\rightarrow$ SR	-	.56***	0.01	✓	Stronger for IND than for COL
SE $\rightarrow$ OE	-	-	n.s	×	No difference between COL and IND
SE $\rightarrow$ PA	-	.53***	0.01	✓	Stronger for IND than for COL
SR $\rightarrow$ PA	-	.21**	0.05	✓	Stronger for IND than for COL
SS $\rightarrow$ SE	-	-	n.s	×	No difference between COL and IND
SS $\rightarrow$ OE	-	-	n.s	×	No difference between COL and IND
SS $\rightarrow$ SR	.39***	.29***	n.s	×	No difference between COL and IND
SS $\rightarrow$ PA	.19**	-	0.08	✓	Marginally stronger for COL than IND
OE $\rightarrow$ SR	.27***	-	0.05	✓	Stronger for COL than for IND
OE $\rightarrow$ PA	.15***	-	0.05	✓	Stronger for COL than for IND
ENV $\rightarrow$ SR	.11*	-	n.s	×	No difference between COL and IND
ENV $\rightarrow$ OE	.29**	.05*	n.s	×	No difference between COL and IND
ENV $\rightarrow$ SE	-	.44***	0.05	✓	Stronger for IND than for COL
ENV $\rightarrow$ SS	.25***	-	n.s	×	No difference between COL and IND
ENV $\rightarrow$ PA	-	-	n.s	×	No difference between COL and IND

Total Effect Analysis

Figure 4.5 shows the total effect of the five SCT constructs on Physical Activity in the respective path models. In the individualist model, Self-Efficacy ($\beta_T = 0.63$, $p < 0.001$), followed by Self-Regulation ($\beta_T = 0.34$, $p < 0.01$) and Physical Environment ($\beta_T = 0.28$, $p < 0.001$), has the strongest total effect on Physical Activity, while Social Support ($\beta_T = 0.09$, $p < 0.05$) and Outcome Expectation have the weakest and no total effects, respectively. However, in the collectivist model, Social Support ($\beta_T = 0.26$, $p < 0.001$), followed by Outcome Expectation ($\beta_T = 0.19$, $p < 0.001$) and Physical Environment ($\beta_T = 0.14$, $p < 0.001$), has the strongest total effect on Physical Activity, while Self-Efficacy and Self-Regulation have the weakest (non-significant) total effects.

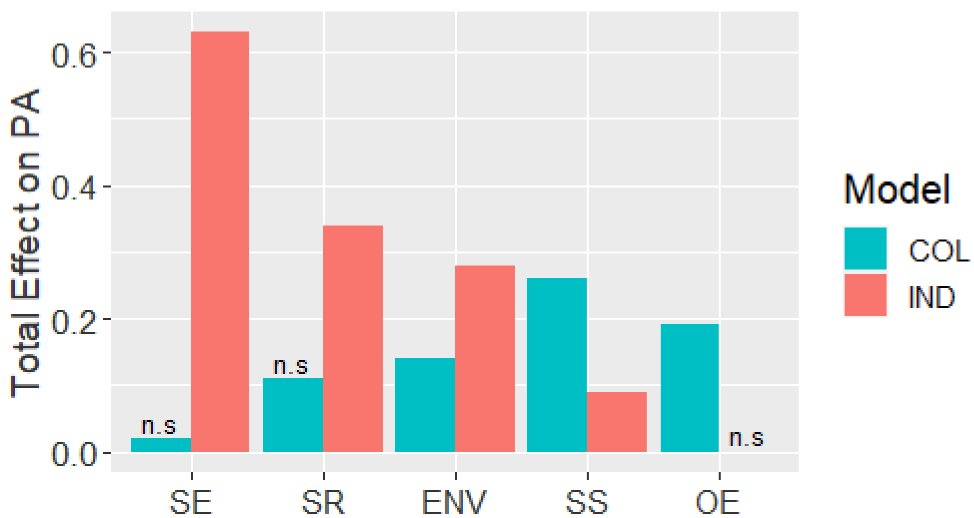

Figure 4.5: Culture-specific total effect of SCT determinants on physical activity (the bars without labels are significant at $p < 0.05$). SE = Self-Efficacy, SR = Self-Regulation, ENV = Physical Environment, SS = Social Support, OE = Outcome Expectation, n.s = non-significant.

Mapping of Culture-Specific Social-Cognitive Determinants to Persuasive Strategies

This subsection provides an answer to the second subquestion of this investigation (RQ1b), "*How can the theoretical determinants be operationalized in the application (technology) domain?*" Table 4.5 down to Table 4.9 show the mapping of the significant culture-specific determinants of physical activity (i.e., the total effects) to three of the main categories of persuasive strategies in the Persuasive System Design (PSD) model [61]. Specifically, Self-Efficacy and Self-Regulation are mapped to the Primary Task Support category (e.g., Goal-Setting, Self-Monitoring, etc.) and the Dialog Support category (e.g., Reward, Suggestion, etc.). On the other hand, Social Support is mapped to the Social Support category (e.g., Cooperation, Social Comparison, etc.). Moreover, Physical Environment and Outcome Expectation are mapped to the Dialog Support category (e.g., Simulation, Behavior Model, etc.) and other persuasive strategies from the literature [188].

Table 4.5: Culture-specific mapping of SCT's Self-Efficacy construct to persuasive strategies in the application domain [27]. "✓" = indicates total effect of Self-Efficacy on Physical Activity is significantly greater than 0.2 ("strong") [171]; "-" = indicates total effect of Self-Efficacy on Physical Activity is not significant in the SCT model.

Strategy	Implementation of Persuasive Strategy	COL	IND
Reduction	Simplify difficult/complex behaviors that require extraneous efforts.	-	✓
Tunneling	Guide user step by step to perform behavior (e.g., using a virtual coach).	-	✓
Role Modeling	Allow users to watch similar others with similar attributes (e.g., age, gender, culture, etc.) perform behavior.	-	✓
Goal-Setting	Allow users to set goals for themselves.	-	✓
Incremental Goal-Setting	Provide users opportunity to begin with an easily achievable goal and increase gradually.	-	✓
Self-Monitoring	Allow users to track their performance and progress.	-	✓
Tailoring	Tailor the user interface and services (e.g., behavior model based on race and gender) to the target group the user belongs.	-	✓
Personalization	Personalize the user interface and messages (e.g., motivational tips and feedback messages targeted at a beginner) to the tarrget user.	-	✓
Behavior Modeling	Simulate bodyweight and other exercises requiring no heavy-duty gym equipment, which can be performed at home.	-	✓

Table 4.6: Culture-specific mapping of SCT's Self-Regulation construct to persuasive strategies in the application domain [27]. "✓" = indicates total effect of Self-Regulation on Physical Activity is significantly greater than 0.2 ("strong") [171]; "-" = indicates total effect of Self-Regulation on Physical Activity is not significant in the SCT model.

Strategy	Implementation of Persuasive Strategy	COL	IND
Self-Monitoring	Allow users to track their performance and achievements.	-	✓
Goal-Setting	Allow users to set goals for themselves.	-	✓
Feedback	Provide users with summary feedback on their progress.	-	✓
Customization	Allow users to customize app to suit their preferences.	-	✓
Role Modeling	Allow users to watch similar others with similar attributes (e.g., age, gender, culture, etc.) perform the target behavior.	-	✓
Reminder	Remind users to perform the target behavior at the opportune moment.	-	✓
Suggestion	Suggest the favorable behaviors to users at the right time and place.	-	✓
Reward	Reward users for achieving a certain goal/milestone.	-	✓

Table 4.7: Culture-specific mapping of SCT's Social Support construct to persuasive strategies in the application domain [27]. The checkmark indicates the strength of applicability of persuasive strategy to the specific group, "✔" = indicates total effect of Social Support on Physical Activity is significantly greater than 0.2 ("strong") [171]; "✓" = indicates total effect of Social Support on Physical Activity is significant but less than 0.2 ("weak"); "-" =l indicates total effect of Social Support on Physical Activity is not significant in the SCT model.

Strategy	Implementation of Persuasive Strategy	COL	IND
Social Learning	Allow users to observe others performing the target behavior and see the outcome.	✔	✓
Social Comparison	Allow users/groups to compare their performance with that of others.	✔	✓
Normative Influence	Provide a means for bringing together users with the same goals to feel the group norms, appraise and visualize one another's achievements.	✔	
Social Facilitation	Provide a means for users to discern when other users are performing the target behavior.	✔	✓
Social Role	Provide users with an actual or virtual coach to teach/show how to perform the target behavior and encourage users by providing reminders and feedback on their performance and progress.	✔	✓
Cooperation	Provide a means for users with the same characteristics, skillsets and goals to cooperate to achieve their target goals.	✔	✓
Social Recognition	Provide a means for users to be publicly recognized when they accomplish certain tasks/goals and win certain challenge/competition.	✔	✓
Competition	Provide a means for users/groups to compete with one another towards achieving a given goal or reward.	✔	✓
Group Customization	Allow one user, in a group-based setting, to tailor on behalf of the other users based on the group preference.	✔	
Reminder	Allow users to be reminded by friends and family to perform behavior.	✔	✓

Table 4.8: Culture-specific mapping of SCT's Physical Environment construct to persuasive strategies in the application domain [27]. The checkmark indicates the strength of applicability of persuasive strategy to the specific group, "✔" = indicates total effect of Physical Environment on Physical Activity is significantly greater than 0.2 ("strong") [171]; "✓" = indicates total effect of Physical Environment on Physical Activity is significant but less than 0.2 ("weak").

Strategy	Implementation of Persuasive Strategy	COL	IND
Behavior Modeling	Simulate bodyweight and other exercises requiring no heavy-duty gym equipment, which can be performed at home.	✓	✔
Suggestion	Suggest to users nearby recreational facilities to carry out specific physical activities at opportune moments.	✓	✔
	Suggest to users physical activities to perform at the right time and place (e.g., take the staircase rather than the elevator, do bodyweight exercise at home).	✓	✔
	Suggest to users good weather conditions in the future to perform certain outdoor physical activities, e.g., running.	✓	✔

Table 4.9: Culture-specific mapping of SCT's Outcome Expectation construct to persuasive strategies in the application domain [27]. The checkmark indicates the strength of applicability of persuasive strategy to the specific group; "✓" = indicates total effect of Outcome Expectation on Physical Activity is significant but less than 0.2 ("weak") [171]; "-" = indicates total effect of Outcome Expectation on Physical Activity is not significant in the SCT model.

Strategy	**Implementation of Persuasive Strategy**	**COL**	**IND**
Simulation	Provide a means for users to observe/establish a link between the cause and effect of their behavior (e.g., through behvior modeling).	✓	-
Conditioning	Provide immediate positive reinforcement (e.g., points) to reward behavior.	✓	-
Biofeedback	Allow user to observe changes in body after exercise.	✓	-
Suggestion	Suggest to users to perform certain physical activities at the right time and place (e.g., taking the staircase rather than the elevator and its benefits).	✓	-
Social Recognition	Allow users to be publically recognized for the achievement of a given goal/milestone (e.g., with a medal).	✓	-
Gain-framed Appeal	Portray the outcome of the target behavior in terms of what user stands to gain when they perform it.	✓	-
Group Endorsement	Provide a means for users to be endorsed by affiliated groups.	✓	-
Expert Endorsement	Provide a means for users to be endorsed by recognized experts in the behavioral domain.	✓	-
Group Surveillance	Allow the success and failure of one user to result in group-based reward and punishment, respectively	✓	-
Deviation Monitoring	Allow users to be informed about their deviation from the norms, standards and goals of the group.	✓	-

4.6.3 Discussion

I have presented a social-cognitive models of the physical activity of people in collectivist and individualist cultures. The multigroup analysis (Table 4.4) showed that the two cultural groups significantly differ in their path models. This is evident in the difference in the Physical Activity variance for the individualist model (R^2 = 45%) and collectivist model (R^2 = 12%) and their corresponding GOF values (59% and 49%, respectively). Both GOF values are categorized as large, indicating that the respective models fit well their empirical data [187]. However, the low R^2 value in the collectivist model indicates that there are other variables (not captured in the model) that may account for Physical Activity variance. The significant difference between both cultural models is also evident in some of the interrelationships. For example, the direct relationship between Perceived Self-Efficacy and Physical Activity is only significant in the individualist model, while that between Outcome Expectation and Physical Activity is only significant in the collectivist model.

Cultural Differences in the SCT Determinants of Physical Activity Behavior

In the light of the first subquestion of this investigation (RQ1a), *"What are the theoretical determinants of the physical-activity behavior of the two target cultures?,"* the main findings are presented in Table 4.10. Evidently, there are significant differences between both cultural groups. In the collectivist culture, Social

Support, Outcome Expectation and Physical Environment are the strongest determinants of Physical Activity. However, in the individualist culture, Self-Efficacy, Physical Environment and Self-Regulation are the strongest determinants of Physical Activity. With regard to the direct relationships, in the collectivist model, Social Support and Outcome Expectation have a small effect size on Physical Activity. On the other hand, in the individualist model, Self-Efficacy and Self-Regulation have a large and a small effect size on Physical Activity, respectively.

Table 4.10: Culture-specific physical-activity determinants profile based on the SCT. The underlined construct indicates a significant total effect on intention to use, with solid and dashed lines representing strong ($\beta \geq 0.2$, $p < 0.05$) and weak effects, respectively. The brackets indicate the numerical difference between each pair of bracketed constructs is less than 0.05.

Model	Order of Strength of Social-Cognitive Determinants of Physical Activity
COL	Social Support, Outcome Expectation, [Physical Environment, Self-Regulation], Self-Efficacy
IND	Self-Efficacy, Self-Regulation, Physical Environment, Social Support, Outcome Expectation

The culture-specific profile can be interpreted in terms of the overall relationship of each SCT construct with Physical Activity. For the individualist culture, the total-effect analysis results suggest that: (1) the higher the self-efficacy beliefs of members of the individualist culture, the more likely they are to engage in physical activity; (2) the higher the self-regulation beliefs of members of the individualist culture, the more likely they are to engage in physical activity; and (3) the higher the availability of active infrastructure (such as gym, recreational parks, cycling tracks, safe and secure neighborhoods, etc.) in the individualist culture, the more likely the members are to engage in physical activity. On the other hand, for the collectivist culture, the total-effect analysis results suggest that: (1) the higher the availability of social support from family and friends, the more likely members of the collectivist culture are to engage in physical-activity behavior; (2) the higher the outcome expectations of members of the collectivist culture (e.g., physical and health benefits of physical activity), the more likely they are to engage in physical activity; and (3) the higher the availability of active infrastructure (such as gym, recreational parks, cycling tracks, safe and secure neighborhoods, etc.) in the collectivist culture, the more likely the members are to engage in physical activity.

Moreover, the results of the multigroup analysis (Table 4.4) show that the effect of Physical Environment on Self-Efficacy is significantly stronger in the individualist culture than in the collectivist culture ($p < 0.05$). In turn, the effect of Self-Efficacy on Self-Regulation and Physical Activity is significantly stronger in the individualist culture than in the collectivist culture ($p < 0.05$). In contrast, the effects of Social Support and Outcome Expectation on Physical Activity are marginally ($p < 0.08$) and significantly ($p < 0.05$) stronger, respectively, in the collectivist culture than in the individualist culture.

Summary of Main Findings

To summarize the main culture-specific findings of this investigation, I proposed an overarching model (Figure 4.6) as an abstraction of the collectivist model (Figure 4.3) and the individualist model (Figure 4.4). The overarching model, in the context of Hofstede's [131] "individualism vs. collectivism" cultural framework, shows the predominant path to engagement in physical activity for the two cultural groups.

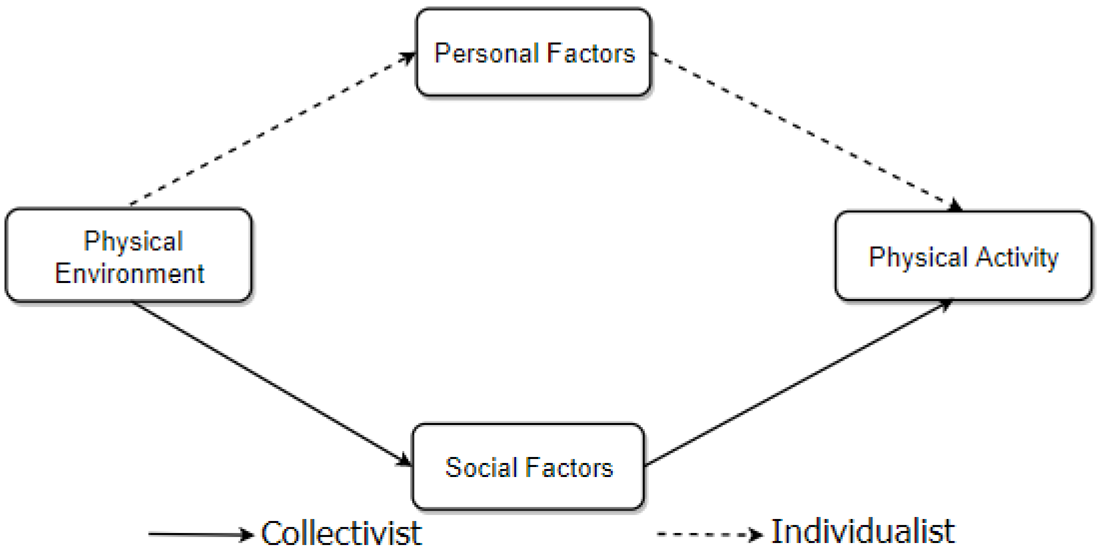

Figure 4.6: Abstract model showing the culture-specific paths to engagement in physical activity [27]

For the individualist culture, the path to engagement in physical activity is Physical Environment → Personal Factors → Physical Activity. On the other hand, for the collectivist culture, the path to engagement in physical activity is Physical Environment → Social Factors → Physical Activity. Moreover, for the collectivist culture, a secondary path is Physical Environment → Outcome Expectation → Physical Activity. However, for brevity, this path is not represented in the abstract model shown in Figure 4.6. The respective culture-specific paths can be regarded as the paths to behavior change in the respective cultures, with the social-cognitive determinants implemented as persuasive strategies in the application domain.

4.7 S1b: Investigation of the Social-Cognitive-Beliefs Profile of the Target Audience and the Moderating Effect of Culture

Having uncovered the social-cognitive determinants of physical activity for both target cultures, I proceed to investigate their social-cognitive-beliefs profile and the moderating effect of culture. In the context of the EMVE-DeCK Framework, this investigation is focused on the "Theory" domain as shown in Figure 4.1. The social-cognitive-beliefs profile represents the ordered set of the average ratings of the six theoretical constructs in the SCT model. Based on this beliefs profile, I will be able to uncover the specific constructs in which the target audience is doing or not doing well at the current time (i.e., as at the time the study was conducted). For example, if the individualist participants' Perceived Self-Regulation is relatively low (say, less than 50%), then there is a needs for a PT intervention that will help improve their Actual Self-Regulation. Similarly, if the collectivist participants' Perceived Social Support is relatively low (say, less than 50%), then there is a need for a PT intervention that will help increase their Actual Social Support.

4.7.1 Research Question and Hypotheses

In the light of the above introduction, this investigation aims to address the subquestion (RQ1b), *"What are the performance levels of the social-cognitive determinants of physical activity in the two target cultures?"* Thus, I formulate a number of hypotheses regarding the perceived levels of the SCT constructs as follows:

H1. Individualists are more likely to have a high level of Perceived Physical Environment than collectivists.

H2. Individualists are more likely to have a high level of Perceived Self-Efficacy than collectivists.

H3. Individualists are more likely to have a high level of Perceived Self-Regulation than collectivists.

H4. Collectivists are more likely to have a high level of Perceived Social Support than individualists.

The hypotheses are informed by the literature and the findings from S1a. Regarding H1, I hypothesize that "*individualists are more likely to have a high level of Perceived Physical Environment than collectivists*" for two reasons. First, the target individualist culture (Canada) is a developed country, while the collectivist culture (Nigeria) is a developing country. For this reason, there are more likely to be enabling environmental factors such as recreational facilities (at parks, work, schools, etc.), cycling/walking tracks, safe and secure environments for physical activity, etc., in Canada than in Nigeria. Moreover, Canada and Nigeria are high- and middle-income countries, respectively [9]. For this reason, people in Canada are more likely to be able to afford access to exercise facilities such as gym than people in Nigeria. Second, based on the total-effect analysis in S1a (Figure 4.5), Physical Environment has a stronger overall effect on Physical Activity in the individualist model ($\beta_T = 0.28$, $p < 0.001$) than in the collectivist model ($\beta_T = 0.14$, $p < 0.001$).

Regarding H2 and H3, I hypothesize that "*individualists are more likely to have a high level of Perceived Self-Efficacy and Self-Regulation than collectivists*" because, based on Hofstede's [131] framework, people in individualist cultures are more likely to be independent and self-motivated towards their goals and aspirations than people in collectivist cultures [189]. Moreover, based on the total-effect analysis in S1a (Figure 4.5), both Self-Efficacy ($\beta_T = 0.63$, $p < 0.001$) and Self-Regulation ($\beta_T = 0.34$, $p < 0.01$) have a stronger overall effect on Physical Activity in the individualist model than in the collectivist model: ($\beta_T = 0.02$, $p = n.s$) and ($\beta_T = 0.11$, $p = n.s$), respectively. Moreover, according to Hofstede's framework, people in collectivist cultures are more likely to be interdependent and seek support from their in-group than people in individualist cultures [189]. Particularly, Social Support has a stronger overall effect on Physical Activity in the collectivist model

($\beta_T = 0.26$, $p < 0.001$) than in the individualist model ($\beta_T = 0.09$, $p < 0.05$). Hence, I hypothesize that "*collectivists are more likely to have a high level of Perceived Social Support than individualists*" (H4).

However, regarding Outcome Expectation and Physical Activity, given the paucity of cross-cultural research and the weak effect of the former on the latter for both cultures, I adopt an exploratory approach.

4.7.2 Data Analysis

I employed a two-way ANOVA based on culture and social-cognitive construct to determine the beliefs profile. However, prior to carrying out the analysis, I conducted a reliability test for all five social-cognitive constructs. Given that the data is not normally distributed, I conducted a McDonald's omega (ω) reliability test [190] using the "ci.reliability" function provided by R's "MBESS" library [191]. The results (at 95% confidence level) showed that all of the social-cognitive constructs met the reliability requirement: $\omega >= 0.7$ [172].

Average Rating of the SCT Determinants of Physical Activity

Figure 4.7 shows the between-group average ratings of all five SCT constructs on a 0-100% scale. Moreover, Figure 4.8 shows the within-group ordering from the highest-rated construct (Outcome Expectation) to the lowest-rated construct (Social Support). In the individualist culture, Outcome Expectation is rated the highest, followed by Physical Environment, Self-Efficacy, Self-Regulation and Social Support. In the collectivist culture, Outcome Expectation is rated the highest, followed by Physical Environment, Self-Regulation, Self-Efficacy and Social Support. Regardless of culture, Outcome Expectation, followed by Physical Environment, is rated the highest, while Social Support is rated the lowest.

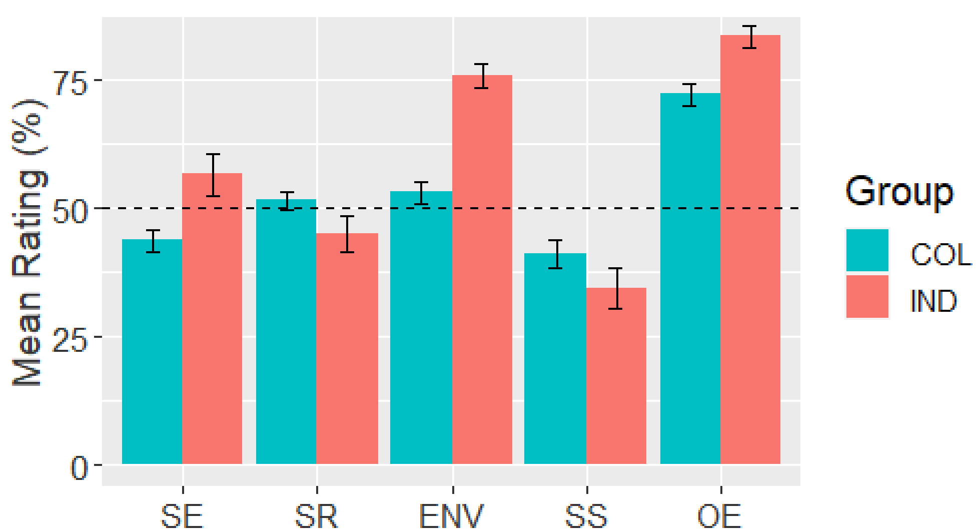

Figure 4.7: Between-group average ratings of the social-cognitive-belief constructs (vertical bar = 95% confidence interval)

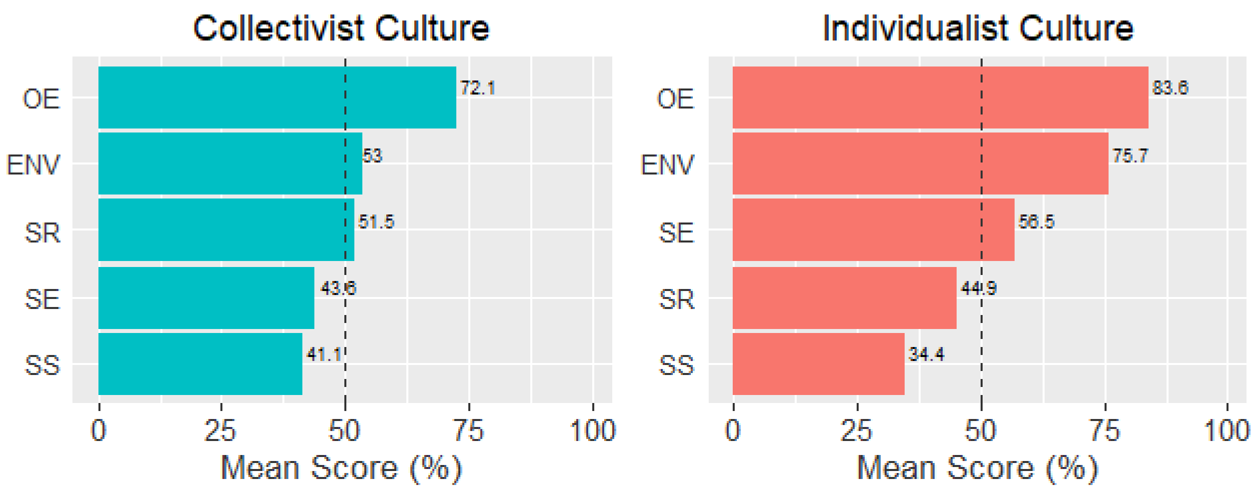

Figure 4.8: Within-group ordering of the social-cognitive-beliefs levels in descending order

Analysis of Variance of the Average Ratings of the SCT Determinants

To determine the moderating effect of culture, I conducted a two-way ANOVA based on culture and SCT construct. The result showed that there is an interaction between both factors [$F_{4,2150} = 46.0$, $\eta_p^2 = 0.08$, $p < 0.001$] and a main effect of culture [$F_{1,2150} = 62.4$, $\eta_p^2 = 0.03$, $p < 0.001$] and SCT construct [$F_{(4,2150} = 218.5$, $\eta_p^2 = 0.29$, $p < 0.001$]. The metric η_p^2 means partial eta squared, which represents effect size. It is a measure of the variance in the dependent variable explained by a given predictor while controlling for other predictors. Mathematically, it is "*the sum of squares effect over the sum of squares effect plus the sum of squares effect error*" (p. 623) [192]. According to Cohen [193], $0.01 \leq \eta_p^2 < 0.06$ represents small effect size, $0.06 \leq \eta_p^2 < 0.14$ represents medium effect size, $\eta_p^2 \geq 0.14$ represents large effect size [194]. The interaction effect size is medium, while the culture effect size is small. However, the SCT construct effect size is large [194]. Due to the interaction, I conducted a between-group and a within-group analysis.

Culture Effect: Between-Group Comparison. Table 4.11 shows the results of the between-group comparisons for each cultural group. The two cultures significantly differ ($p < 0.01$) in all of the five SCT constructs. The effect of size of the group difference in Self-Regulation (SR) and Social Support (SS) is small, while that for Self-Efficacy (SE) and Outcome Expectation (OE) is medium. However, the effect size of the group difference ($\eta_p^2 = 0.32$) in Physical Environment (ENV) is large.

SCT Construct Effect: Within-Group Comparison. Table 4.12 shows the results of the within-group comparisons for the two cultural groups. Regardless of culture, each pair of SCT constructs significantly differ ($p < 0.01$), except for a few pairs. The symbol d is fully regarded as Cohen's d metric, which is an effect size representing the standardized difference between two means. It is calculated by dividing the estimated difference between two means by the residual standard deviation of the data [195]. The effect size of the mean difference between two SCT constructs in each group ranges from very small to huge effect sizes.

Table 4.11: Between-group comparisons of the collectivist and individualist cultures' mean ratings of the social-cognitive constructs. η_p^2 = partial eta squared representing effect size. $\eta_p^2 = 0.01$: small effect size, $\eta_p^2 = 0.06$: medium effect size, $\eta_p^2 = 0.14$: large effect size [193][195].

Construct	**COL**	**IND**	***p*-Value**	**η_p^2-Value**	**Remark on Effect Size**
SE	43.6	56.5	0.001	0.07	Medium
SR	51.5	44.9	0.001	0.03	Small
ENV	53.0	75.7	0.001	0.32	Large
SS	41.1	34.4	0.010	0.02	Small
OE	72.1	83.6	0.001	0.11	Medium

Table 4.12: Within-group pairwise comparisons of the mean ratings of the social-cognitive constructs. M = Mean score of SCT onstruct, d = Cohen's d metric representing effect size. $d = 0.01$: very small effect size, $d = 0.20$: small effect size, $d = 0.50$: mediun effect size, $d = 0.80$: large effect size, $d = 1.20$: very large effect size, $d = 2.0$: huge effect size [195].

	COL				**IND**			
	M1	**M2**	***p*-Value**	***d***	**M1**	**M2**	***p*-Value**	***d***
OE – ENV	72.1	53.0	0.0001	0.99	83.6	75.7	0.0001	0.52
OE – SR	72.1	51.5	0.0001	1.07	83.6	44.9	0.0001	2.15
OE – SE	72.1	43.6	0.0001	1.54	83.6	56.5	0.0001	1.52
OE – SS	72.1	41.1	0.0001	1.58	83.6	34.4	0.0001	2.58
ENV – SR	53.0	51.5	n.s	0.08	75.7	44.9	0.0001	1.63
ENV – SE	53.0	43.6	0.0001	0.55	75.7	56.5	0.0001	1.00
ENV – SS	53.0	41.1	0.0001	0.59	75.7	34.4	0.0001	2.05
SR – SS	51.5	41.1	0.0001	0.51	44.9	34.4	0.0033	0.43
SR – SE	51.5	43.6	0.0001	0.48	44.9	56.5	0.0001	0.63
SE – SS	43.6	41.1	n.s	0.04	56.5	34.4	0.0001	1.06

As shown in Figure 4.8 and statistically evident in Table 4.12, the biggest effect size is the mean difference between Outcome Expectation (OE) and Social Support (SS) in the individualist group ($d = 2.58$) as well as in the collectivist group ($d = 1.58$). This difference indicates that the Outcome Expectation of either cultural group, in reality, is way higher than its Social Support. Moreover, in the individualist group, the smallest effect size ($d = 0.43$) is the mean difference between Self-Regulation (SR) and Social Support (SS). This result indicates that, in reality, the Self-Regulation and Social Support levels (which are the two lowest social-cognitive beliefs for the individualist group) differ the least compared with any other pair of SCT constructs. However, in the collectivist group, the smallest effect size ($d = 0.04$) is the mean difference between Self-Efficacy (SE) and Social Support (SS). This result indicates that, in reality, the Self-Efficacy and Social Support levels (which are the two lowest social-cognitive beliefs for the collectivist group) differ the least compared with any other pair of SCT constructs.

Reported Weekly Physical Activity Level

Apart from the social-cognitive-belief levels, I computed the physical activity levels (PALs) of the two target groups for the last seven-day period prior to their completing the questionnaire. The PAL is the sum of the light-, moderate- and vigorous-intensity activities reported by the participants. Figure 4.9 and Figure 4.10 show the PAL histograms in MET-mins for the collectivist and individualist cultures, respectively. For the collectivist group, the average value is 1989 MET-mins, with 12.4% and 14.7% of the participants reporting a PAL that is less than 600 MET-mins (moderate PAL) and above 3000 MET-mins (high PAL), respectively [7]. Hence, 72.9% reported a PAL that is within moderate and high levels. Similarly, for the individualist group, the average value is 2222 MET-mins, with 11.1% and 28.6% of the participants reporting a PAL that is less than 600 MET-mins (moderate PAL) and above 3000 MET-mins (high PAL), respectively. Hence, 60.3% reported a PAL that is within moderate and high levels. A one-way ANOVA showed that there is no significant difference ($p = 0.30$) between the average values of both cultures.

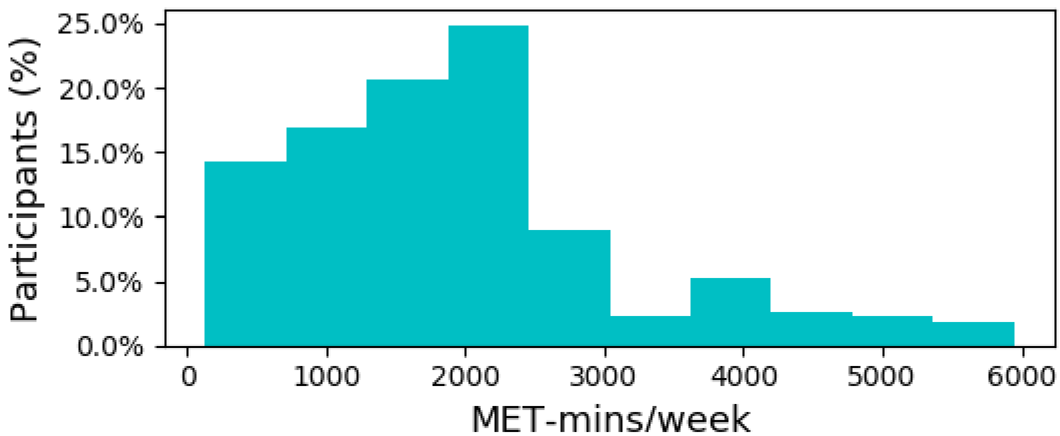

Figure 4.9: Collectivist physical activity level. Outliers (>6000 MET-mins) excluded, n = 266, mean = 1989 MET-mins, <600 MET-mins = 12.4%, >3000 MET-mins = 14.7%.

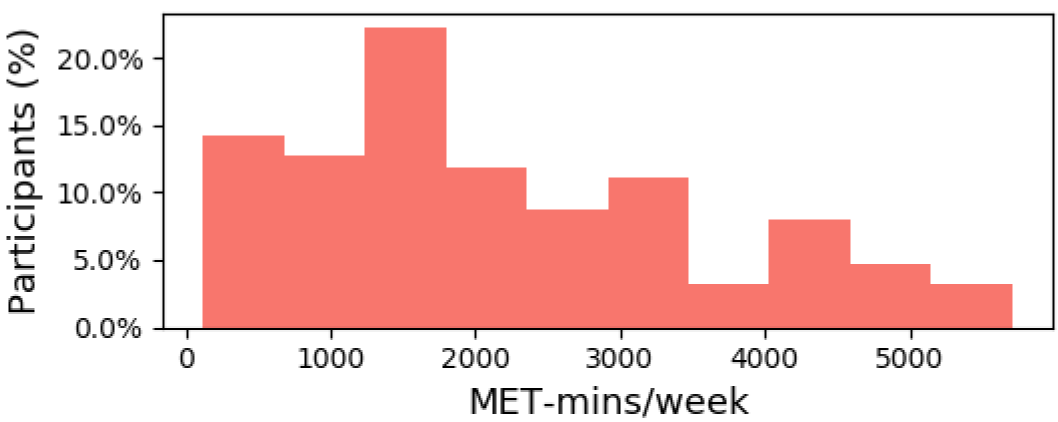

Figure 4.10: Individualist physical activity level. Outliers (>6000 MET-mins) excluded, n = 126, mean = 2222 MET-mins, <600 MET-mins = 11.1%, >3000 MET-mins = 28.6%.

4.7.3 Discussion

I have presented the social-cognitive-beliefs profile and the IPMAX for the collectivist and individualist cultures. Regarding the performance levels, for the individualist culture, Outcome Expectation (M = 83.6%) is the highest, followed by Perceived Physical Environment (M = 75.7%), Perceived Self-Efficacy (M = 56.5%), Perceived Self-Regulation (M = 44.9%) and Social Support (M = 34.4%), with each construct being significantly higher than the one that followed ($p < 0.001$). Similarly, for the collectivist culture, Outcome Expectation (M = 72.1%) is the highest, followed by Perceived Physical Environment (M = 53.0%), Perceived Self-Regulation (M = 51.5%), Perceived Self-Efficacy (M = 43.6%) and Perceived Social Support (M = 41.1%), with each construct being significantly higher than the one that followed ($p < 0.001$). The only exception is that the difference between Perceived Self-Efficacy (M = 43.6%) and Self-Regulation (M = 51.5%), and between Self-Regulation (M = 51.5%) and Physical Environment (M = 53.0%) is not statistically significant at $p < 0.05$. In particular, regardless of culture, the effect size of the difference between Outcome Expectation (the most highly rated) and the other SCT constructs are either large, very large or huge (i.e., $d = \geq 0.8$). Similarly, the effect size of the difference between Perceived Physical Environment (the second most highly rated) and the other SCT constructs is either large, very large or huge as well. The only exception is the difference between Perceived Physical Environment and Perceived Self-Efficacy in the collectivist group, which effect size is medium ($d = 0.55$).

Highest-Performing SCT Constructs among Participants

Figure 4.8 plots show that Outcome Expectation and Perceived Physical Environment have the highest performance levels in both cultures: individualist culture (83.6% and 75.7%, respectively) and collectivist culture (75.21% and 53%, respectively). Comparatively, the between-group analysis showed that Outcome Expectation is significantly higher ($p < 0.001$) for the individualist group (M = 83.6%) than for the collectivist group (M = 72.1%). The effect size of the difference between both groups' means is medium. Similarly, Perceived Physical Environment is significantly higher ($p < 0.001$) in the individualist group (M = 75.7%) than in the collectivist group (M = 53.0%). The effect size of the difference between both groups' means is large.

The above findings may not be surprising given that Canada (a high-income country) is more developed than Nigeria (a middle-income country). As such, it is more likely that physical-activity facilities (e.g., gyms) will be available to Canadians to perform physical activity and experience its outcomes/benefits (physical, mental and social) than to Nigerians. Moreover, there are more likely to be fitness-related adverts on the benefits of exercise by role models in the traditional media (e.g., television) and social media (e.g., YouTube) in Canada than in Nigeria. For these reasons, the Outcome Expectation of the Canadian group (individualist culture) turned out to be higher than that of the Nigeria group (collectivist culture), with the effect size of the group (cultural) difference being medium.

The same explanation can be put forward for why Perceived Self-Efficacy is higher for the individualist group (M = 56.5%) than for the collectivist group (M = 43.6%). There is more social/role modeling in the individualist culture than in the collectivist culture. According to Bandura [93], social modeling (a form of vicarious modeling) in the media (a form of verbal persuasion) is one of the strongest sources of self-efficacy. Thus, given the higher availability of physical-activity facilities (see Table 4.11) and the stronger effect of Perceived Physical Environment on Perceived Self-Efficacy in the individualist SCT model (see Table 4.4), the Perceived Self-Efficacy of individualist group turned out to be higher than that of the collectivist group, with the effect size of the group difference being large.

Lowest-Performing SCT Constructs among Participants

Figure 4.8 shows that Perceived Social Support has the lowest performance level in both cultures, which is in line with the prior finding that lack of support and encouragement from family and friends is *"the major barrier to physical activity"* (p. 13) [25]. Particularly, the between-group comparison showed that Social Support is significantly lower for the individualist group (M = 34.4%) than for the collectivist group (M = 41.1%), with the effect size of the group difference being small. This result may not be surprising given that Nigeria, based on Hofstede's [131] cultural framework, is classified as a collectivist culture (in which people work together to achieve collective goals), while Canada is classified as an individualist culture (in which people work more independently to achieve personal goals). Thus, people are less likely to get social support in the individualist culture than in the collectivist culture. Moreover, unexpectedly, Perceived Self-Regulation turned out to be higher for the collectivist group (M = 51.5%) than for the individualist group (M = 44.9%), with the effect size of the group difference being small. This result may have come as a surprise as one would have expected Perceived Self-Regulation to be significantly higher for the individualist group than for the collectivist group given that people in the former culture are more independent and self-motivated. That said, one possible explanation for the counter-intuitive finding is that Perceived Social Support, which has a direct effect on Perceived Self-Regulation in the SCT models for both cultures, is higher for the collectivist group (M = 41.1%) than for the individualist group (M = 34.4%). As shown in Figure 4.3 and Figure 4.4, the direct effect of Perceived Social Support on Perceived Self-Regulation is higher for the collectivist group (β = 0.39, $p < 0.001$) than for the individualist group (β = 0.29, $p < 0.001$). Thus, the Perceived Self-Regulation level turned out to be higher for the collectivist group than for the individualist group.

4.7.4 Summary of Findings

In the light of S1b's hypotheses, I summarize the main findings (with regard to engagement in physical activity) as follows:

1. **Support for H1:** Individualists are more likely to have a high level of Perceived Physical Environment than collectivists. This may be due to an individualist culture such as Canada being more technologically and economically developed than a collectivist culture such as Nigeria.

2. **Support for H2:** Individualists are more likely to have a high level of Perceived Self-Efficacy than collectivists. This may be due to individualist people being more likely to be independent than collectivist people.

3. **Counter-support for H3:** Collectivists are more likely to have a high level of Perceived Self-Regulation than individualists. This may be due to collectivist people being more likely to seek and get social support than individualist people.

4. **Support for H4:**. Collectivists are more likely to have a high level of Perceived Social Support than individualists. This may due to collectivist people being more likely to be inter-dependent than individualist people.

5. **Exploratory Result 1:** Individualists are more likely to have a high level of Outcome Expectation than collectivists. This may be due to Canada (the individualist group) being more likely to have access to health and fitness information on the web, mass and social media than Nigeria (the collectivist group).

6. **Exploratory Result 2:** There is no significant difference between collectivist and individualist people in terms of their Physical Activity levels.

4.8 Triangulation of Findings from S1a and S1b using Importance Performance Matrix

Having known the culture-specific social-cognitive determinants of physical activity (from S1a) and their average scores (from S1b), I proceed to carry out an Importance Performance Matrix (IPMAX) analysis [72]. Essentially, the IPMAX is employed to understand the operational strategy for an intervention (e.g., a marketing campaign; in my case, the implementation of a PHA for the respective target groups). Specifically, the IPMAX helps in determining which of the determinants of physical activity need to be targeted in the respective cultures to improve the physical activity level of the target users. *Importance* refers to the magnitude of the total effect of a social-cognitive determinant on Physical Activity (from S1a) [72]. On the other hand, *performance* refers to the average rating of each determinant in the social-cognitive model [72].

Table 4.13 [72][196] shows the four quadrants that are in the IPMAX and their explanation. The ultimate focus of the intervention is on quadrant 2: SCT determinants that are found to be important in S1a, but in S1b are at a poor (low) level at the moment. Determinants in this quadrant ought to be improved by the intervention to shift them to quadrant 1. Figure 4.11 shows the IPMAX plot for both cultures based on a 0-100% scale. For example, for the individualist culture, Self-Regulation falls into quadrant 2, with importance and performance scores of 34% ($\beta_T = 0.34$, $p < 0.01$) and 44.9%, respectively. For the collectivist culture, Social Support falls into quadrant 2, with importance and performance scores of 26% ($\beta_T = 0.26$, $p < 0.001$) and 41.1%, respectively. Both constructs ought to be improved in the respective target groups.

Table 4.13: Explanation of IPMAX quadrants in relation to participants' SCT construct scores

Quadrant 4 (Top-Left)	**Quadrant 1 (Top-Right)**
SCT determinants that are considered to be less important, yet are at a good (high) level at the moment. Determinants in this quadrant ought not to be prioritized by the intervention.	SCT determinants that are considered to be important and are at a good (high) level at the moment. Determinants in this quadrant ought to be maintained by the intervention.
Quadrant 3 (Bottom-Left)	**Quadrant 2 (Bottom-Right)**
SCT determinants that are considered to be less important and are at a poor (low) level at the moment. Determinants in this quadrant ought not to be the focus of the intervention.	SCT determinants that are considered to be important, but are at a poor (low) level at the moment. Determinants in this quadrant ought to be improved by the intervention to shift them to quadrant 1.

Figure 4.11: SCT Determinants IPMAX for collectivist and individualist cultures (importance > 20% implies strong determinants [171], while performance > 50% implies high score)

4.8.1 Correlation between SCT Determinant Importance and Performance Level

Overall, the IPMAX plot shows that there is no correlation between the perceived levels of the SCT constructs and their total effects on Physical Activity. For example, the perceived level of Outcome Expectation is the highest (over 70% for the collectivist culture and 80% for the individualist culture). However, their corresponding total effects (importance levels) are not. In fact, for the individualist culture, among the six SCT constructs, the importance level of Outcome Expectation turns out to be the least.

4.8.2 Intervention Strategy to Improve Physical Activity Level

Regarding PAL/week, Figure 4.9 and Figure 4.10 show that about 87.6% of the collectivist participants and 88.9% of the individualist participants reported that they were moderately active (PAL/week > 600 MET-mins/week). However, their reported MET-mins/week may not be reliable due to participants' recall bias and lack of honesty [34][35][36]. Research [197] shows that participants usually overestimate their reported PAL. For example, Watkinson et al. [198] found that 63.3% of their study participants (n = 231) were inactive based on objective measurement. However, of these inactive participants, 45.9% rated themselves as active. In most IPAQ-based studies, it was found that "*the IPAQ-SF [Short Form] overestimated physical activity level by 36 to 173 percent*" (p. 1) [199]. Thus, in the current study, it may not be reliable to conclude that the target populations are already active and, as a result, do not need an intervention. Rather, I based the need for an intervention on the huge amount of prior research [3][4], which found that many people in both developed and developing countries do not meet the recommended weekly PAL required to be active. For example, recent studies found that 82% of Canadians [200] and and 41% of Nigerians [201] were inactive.

Having discussed the culture-specific performance levels of the social-cognitive determinants and how the two cultures differ, it is pertinent to discuss them side by side the total-effect values using the IPMAX for the purpose of proffering an intervention strategy for the respective cultures. Based on the explanation of the four quadrants shown in Figure 4.11, the focus of the PT intervention should be on quadrant 2 (those determinants of physical activity that are of high importance but performing low at the moment). In this regard, the proposed intervention should focus on improving Social Support (mapped to Cooperation and Social Learning) for the target population as shown in Figure 4.12. However, for the individualist culture, the intervention should focus on improving personal factors such as Self-Regulation (mapped to Goal-Setting and Self-Monitoring) for the target population.

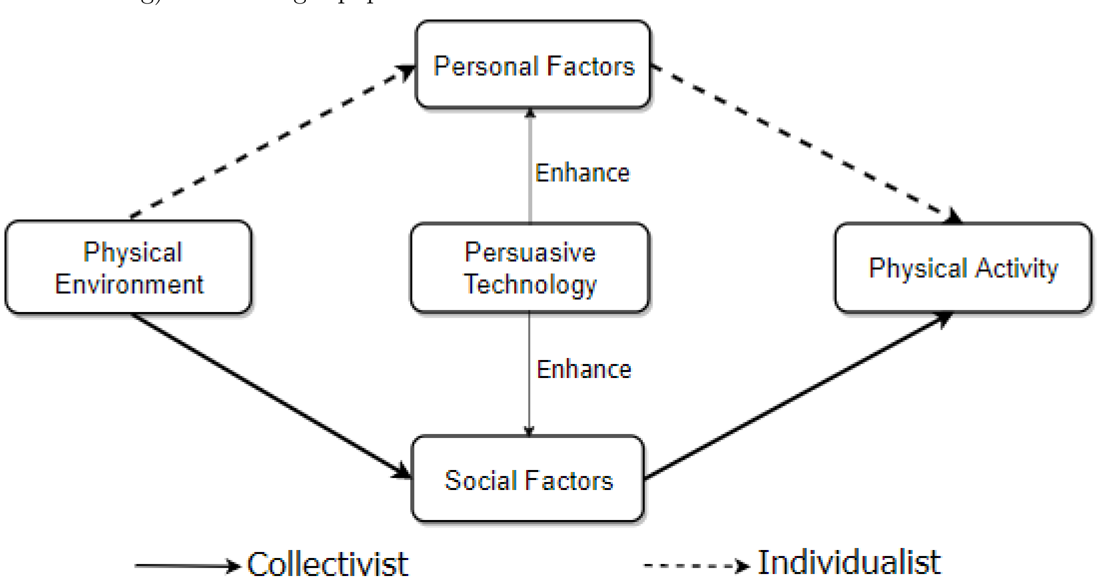

Figure 4.12: PT intervention strategy to improve social-cognitive determinants of physical activity

4.9 Conclusion

In this study, I presented the results of two investigations (S1a and S1b), which provide answers to the first research question (RQ1), "***How can behavior change theory be employed to inform a PT intervention to promote physical activity?***" In S1a, I found that, in the collectivist culture, Social Support is the strongest social-cognitive determinant of Physical Activity. However, in the individualist culture, Self-Efficacy and Self-Regulation are the strongest social-cognitive determinants of Physical Activity. Secondly, in S1b, I uncovered the social-cognitive-beliefs profile of the two cultural groups. Particularly, the individualist group has higher levels of Physical Environment, Self-Efficacy and Outcome Expectation, while the collectivist group has higher levels of Social Support and Self-Regulation. Further, I conducted an IPMAX analysis to synthesize the findings from both investigations and made recommendations on PT intervention strategies. I found that, the levels of Social Support in the collectivist culture is relatively low (below 50%) despite its importance in the collectivist social-cognitive model as a strong determinant of Physical Activity. Moreover, the levels of Self-Regulation (below 50%) and Self-Efficacy (a little above 50%) are relatively low in the individualist culture despite their importance in the individualist social-cognitive model as the strongest determinants of Physical Activity. Consequently, due to the strong overall effect of Social Support on Physical Activity and its low performance level among the collectivist participants, the focus of the proposed PT intervention should be on increasing Social Support for the collectivist group. On the other hand, due to the strong overall effect of Self-Efficacy and Self-Regulation on Physical Activity and their relatively low performance level among the individualist participants, the focus of the PT intervention should be on improving both determinants for the individualist group. In S2, I investigate the receptiveness of both cultures to a number of the persuasive strategies that operationalize the culture-specific social-cognitive determinants in the application domain. This study will help to uncover the subset of persuasive strategies that the PT intervention should target in the respective cultures.

4.10 Contributions

The first user study (S1) makes a number of contributions to the PT literature in the area of cross-cultural research and group-based personalization. Firstly, S1a showed that culture moderates the theoretical determinants of behavior using the SCT as a behavioral framework for comparative analysis. Secondly, it showed that personal factors (Self-Efficacy and Self-Regulation) are the strongest determinants of physical activity in the individualist culture, while social factors (Social Support) are the strongest determinants of physical activity in the collectivist culture. Thirdly, it showed a mapping of the five social-cognitive constructs of interest in the theory domain to corresponding persuasive strategies in the application domain. Specifically, Self-Efficacy and Self-Regulation are mapped to Oinas-Kukkonen and Harjumaa's PSD model's [61] Primary Task Support category (e.g., Goal-Setting, Self-Monitoring and Behavior Modeling) and the Dialog Support category (e.g., Reward, Reminder and Suggestion). Moreover, Social Support is mapped to the Social Support category (e.g., Cooperation, Social Learning and Social Comparison). Finally, it provided a set of PT design guidelines, based on empirical evidence, for designing culture-tailored PHAs for the two target groups.

4.11 Limitations and Future Work

The main limitation of the study (S1) is that its findings are based on self-report, especially with regard to the target construct (Physical Activity), which was based on participants' subjective report of their physical activity levels for the last seven days. This may threaten the generalizability of the empirical findings to the application domain, in which the actual physical activity levels of participants are objectively measured, e.g., by using a fitness app. The second limitation of the study is that it used convenience samples (university students), which may threaten the generalizability of the findings to non-students. The third limitation of the study is that only two countries (Canada and Nigeria) were selected as case studies to represent the two main types of cultures (individualist and collectivist). This may threaten the generalizability of the culture-specific findings to other collectivist and individualist countries. Thus, further studies should be conducted in the future in the context of SCT to investigate the generalizability of the current findings to other countries.

5 Receptiveness to Persuasive Strategies

This chapter focuses on the third step of the EMVE-DeCK Framework, which is the second user study of the dissertation. The study (S2) entails *validating* the significant theoretical determinants of physical activity (from S1) in the application (technology) domain. It is situated in the EMVE-DeCK Framework as shown in Figure 5.1. This chapter presents three investigations (S2a, S2b and S2c) based on six persuasive strategies (features) illustrated on storyboards. Two of the six strategies are personal (Goal-Setting/Self-Monitoring and Reward), which operationalize Self-Efficacy and Self-Regulation in the application domain. The other four strategies are social (Cooperation, Social Learning, Social Comparison and Competition), which operationalize Social Support.

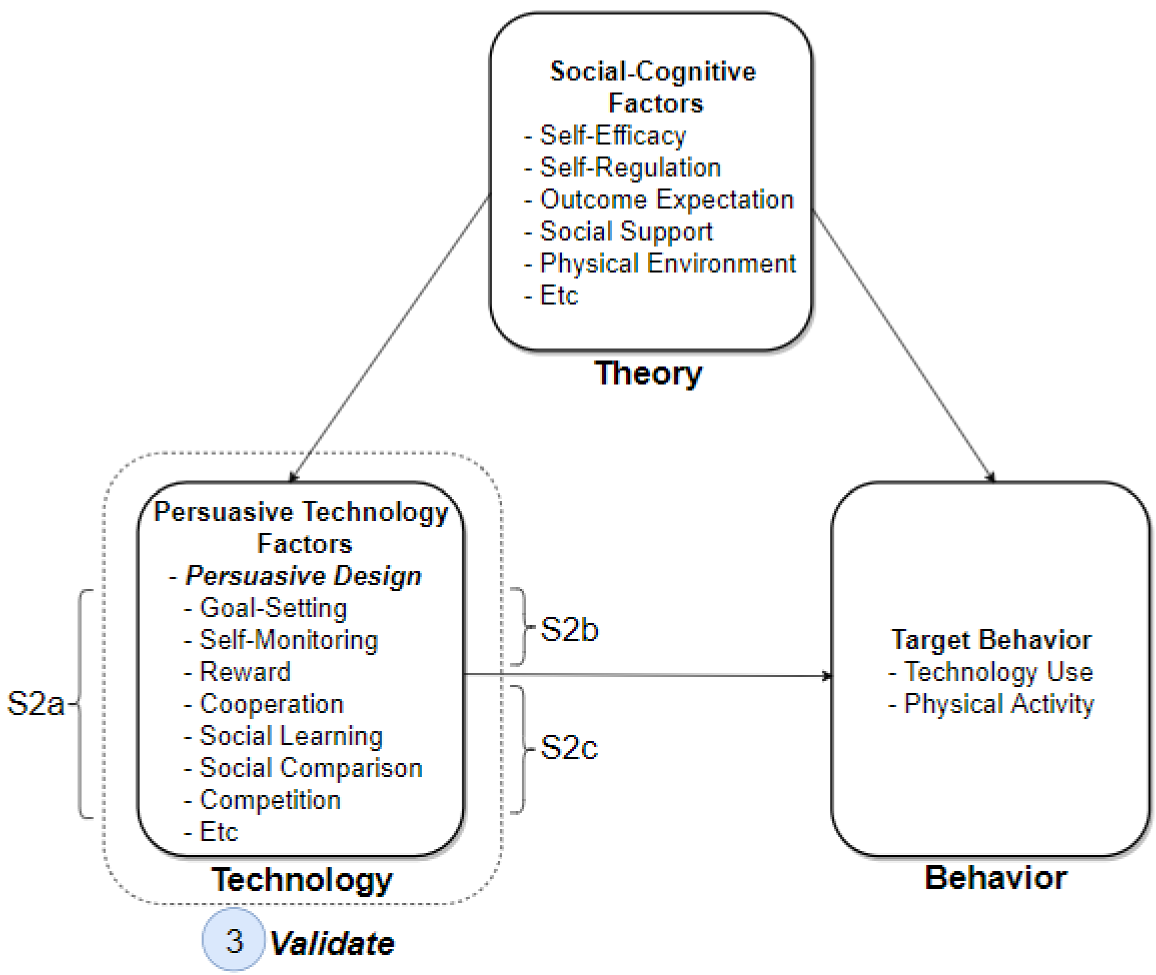

Figure 5.1: Situating the persuasion profile study in the EMVE-DeCK Framework

The first investigation (S2a) examines the receptiveness of the target audience to the six persuasive strategies using a quantitative approach. The second investigation (S2b) examines the receptiveness of the target audience to the personal strategies using a qualitative approach. The third study (S2c) examines the receptiveness of the target audience to the social strategies using a qualitative approach. In both investigations, I look at how both cultures differ in their levels of receptiveness to the strategies. Fourthly, using triangulation, I synthesize the findings from S2a, S2b and S2c. I also synthesize the findings from S1 and S2 at a higher level. Finally, I recommend, for each culture, specific strategies that will be implemented as persuasive features in an actual persuasive health application (PHA), which will be evaluated in the field.

5.1 Motivation

This study is particularly important because it will help to confirm or refute the initial findings from S1 (in the theory domain), thereby, if validated, making them more consistent and reliable. Secondly, it will help to narrow down the set of persuasive strategies that should be implemented for each cultural group in the field. For example, in the individualist culture, Self-Efficacy and Self-Regulation in S1 were mapped to Goal-Setting, Self-Monitoring, Reward, Reminder, Reduction, Tunneling, etc. On the other hand, in the collectivist culture, Social Support was mapped to Cooperation, Social Leaning, Social Comparison, Competition, Social Recognition, Normative Influence, etc. In practical settings, due to limited resources (e.g., time, money and programming expertise), persuasive technology (PT) designers may not be able to implement all of these persuasive strategies. As a result, they may have to make hard design choices in terms of the persuasive strategies that should be prioritized. For example, for the collectivist culture, "*Does the designer choose Cooperation over Competition or vice versa?*" The need to choose a subset of strategies that are most likely to be effective for the two different types of culture necessitates the current study [202].

5.2 Related Work

In the PT domain, a substantial number of studies have been conducted to uncover users' receptiveness to persuasive strategies with a view to tailoring persuasive applications to different target populations. Such studies usually look at demographic variables such as gender, age and culture as potential dimensions based on which persuasive applications can be tailored to the target users to make them more effective. Kaptein et al. [203] conducted a study to examine the relationship between users' receptiveness to persuasive cues and persuasive requests. They found that the more receptive people are to persuasive cues, the more likely they will comply with persuasive requests implemented in PTs, e.g., request to provide their email address when they are browsing a website. Orji et al. [204][121] examined the effect of culture, gender and age on users' receptiveness to Cialdini's [148] principles of persuasion using subjects from North America and Asia as a case study. The Cialdini's principles include Commitment, Reciprocity, Authority, Liking, Consensus and Scarcity. The authors found that, regardless of all three demographic factors, users are most likely to be receptive to the Commitment principle, which is basically mapped to Goal-Setting in the PT domain [122]. In the second study, Orji [121] found that users from collectivist cultures are more likely to be receptive to Authority, Reciprocity, Liking and Consensus than users from individualist cultures.

As a follow-up to Orji et al.'s [121][204] studies, Oyibo et al. [122][123] carried out two studies to examine the effect of culture [122] and gender [123] on users' receptiveness to all six Cialdini's principles of persuasion using Canada (individualist culture) and Nigeria (collectivist culture) as a case study. The authors replicated Orji et al.'s [121][204] main finding: regardless of culture and gender, users are most likely to be receptive to the Commitment principle. Moreover, Oyibo et al. [122] found that individualist users are more likely to be receptive to Reciprocity, Liking and Consensus than collectivist users, while collectivist users are more likely to be receptive to Authority than individualist users. Secondly, Oyibo et al. [189] investigated the moderating effect of culture on the influence of gender and age on Reward, Competition, Social Comparison and Social Learning using Nigeria (collectivist culture) and Canada (individualist culture) as a case study. They found that males are more likely to be receptive to Reward and Competition than females in the collectivist culture, but no difference between both genders in the individualist culture. They also found that younger people are more likely to be receptive to Social Comparison and Social Learning than older people in the collectivist culture but no difference was found between both age groups in the individualist culture. Moreover, they found that younger people are more likely to be receptive to Competition than older people in both cultures.

Finally, Shih and Jheng [202] conducted a study on users' receptiveness to 12 persuasive strategies in the energy-conservation domain. They found that the study participants are more receptive to non-social strategies such as Reduction, Reward, Simulation, Suggestion and Reminder than social strategies such as Cooperation, Comparison and Normative Influence. Moreover, they found that older people are more receptive to Self-Monitoring, Simulation and Cooperation, while younger people are more receptive to Reward.

One of the main limitations of the reviewed studies is that, apart from most of them being based on Cialdini's principles, they were not carried out in the specific domain of physical activity. Most importantly, they were not carried out with the intention to validate prior findings from the theory domain. Finally, the studies did not attempt to triangulate quantitative and qualitative findings to increase consistency and reliability, which are at the heart of the current study.

5.3 Study Objective

Recall that, in S1, I found that, in the theory domain, personal factors (Self-Efficacy and Self-Regulation) are the strongest determinants of physical activity in the individualist culture. Both social-cognitive determinants were mapped to personal strategies (e.g., Goal-Setting, Self-Monitoring and Reward) in the application domain. In contrast, I found that social factors (Social Support) are the strongest determinants of physical activity in the collectivist culture. Social Support was mapped to social strategies (e.g., Cooperation, Social Learning and Social Comparison) in the application domain. Hence, in the current study (S2), I set out to investigate the receptiveness of both cultures to a subset of the persuasive strategies to which Self-Efficacy, Self-Regulation and Social Support were mapped in S1. The subset of persuasive strategies include Goal-Setting/Self-Monitoring, Reward, Competition, Cooperation, Social Learning and Social Comparison, which are drawn from the Persuasive System Design (PSD) model [61].

I chose this subset of strategies because all of the strategies (over 20) to which the three social-cognitive determinants of physical activity are mapped in S1 could not have been investigated due to participant fatigue. The second reason for choosing the subset of six strategies is that prior research [205] shows they have the potential to motivate behavior change. Hence, most fitness apps often include them in their persuasive design. For example, in a systematic review of mobile fitness apps, Matthews et al. [15] found that 70% of the apps featured Self-Monitoring, 40% featured Social Comparison, 25% featured Competition, 25% featured Social Learning, 20% featured Reward, and 5% featured Cooperation. Moreover, in the broader domain of health and wellness, in a systematic review, Orji et al. [22] found that 91% of the studies that investigated Competition; 87% of those that investigated Social Support, Comparison and Learning (Sharing); and 82% of those that investigated Reward, had positive results. They also found that 80% of the studies that investigated Cooperation; 79% of those that investigated Self-Monitoring; and 69% of those that investigated Goal-Setting, had positive results. Hence, given their common employment in fitness apps and potential effectiveness, I decided to study all six strategies for possible consideration in the proposed PHA aimed to motivate the physical activity of the target audience.

5.4 Research Questions

The current study aims to answer the second research question of the dissertation (RQ2), "***What are the persuasion profiles of the target audience in the application domain and how are they moderated by culture?***." This research question is broken down into the following two subquestions:

RQ2a. How do the two types of culture differ in their receptiveness to commonly employed *personal* persuasive strategies (features) in the application domain?

RQ2b. How do the two types of culture differ in their receptiveness to commonly employed *social* persuasive strategies (features) in the application domain?

5.5 Study Method

To answer the above research questions, I employed exercise-based storyboards illustrating the six persuasive features. In prior work (e.g., [33], [202]), storyboards have been successfully employed to uncover useful PT design guidelines from potential users. In the current study, I aim to uncover the persuasion profiles of the target users in the two types of culture for the purpose of realizing a culture-tailored PT intervention. All six persuasive features are defined in Table 5.1.

Table 5.1: Investigated persuasive features and their definitions. Goal-Setting and Self-Monitoring were implemented and illustrated as a composite (complementary) feature in the storyboard.

Persuasive Feature	Definition of Persuasive Feature
Goal-Setting	Goal-Setting is a persuasive feature that allows users to set goals prior to tracking their performance of the target behavior and progress over time.
Self-Monitoring	Self-Monitoring is a persuasive feature that allows users to keep track of their performance of the target behavior and progress over time.
Reward	Reward is a persuasive feature that allows incentives such as points, badges, levels, etc., to be awarded to users upon achieving their goals or a certain milestone.
Cooperation	Cooperation is a persuasive feature that allows two or more users to work together to achieve a collective (joint) goal and/or reward.
Social Learning	Social Learning is a persuasive feature that allows users in a collaborative setting to observe the behavior performance, progress and achievements of others.
Social Comparison	Social Comparison is a persuasive feature that allows users in a collaborative setting to view and compare their performance, progress and achievements.
Competition	Competition is a persuasive feature that allows users to compete against one another towards achieving a mutually exclusive goal or reward.

5.5.1 Study Design

Th study aims to use triangulation method (quantitative and qualitative) to answer each subquestion. The study design entails triangulation and synthesis of findings from S2a (on one hand) with those from S2b and S2c (on the other hand). Each of the three investigations are explained thus:

(a) S2a provides answers to RQ2a and RQ2b using a quantitative approach. It investigates the receptiveness of the target audience to the personal and social strategies and the moderating effect of culture.

(b) S2b provides answers to RQ2a using a qualitative approach. It investigates the receptiveness of the target audience to the personal strategies and the moderating effect of culture.

(c) S2c provides answers to RQ2b using a qualitative approach. It investigates the receptiveness of the target audience to the social strategies and the moderating effect of culture.

5.5.2 Data Collection

The user study (online survey) was submitted to the University of Saskatchewan Behavioral Research Ethics Board for review. After approval, it was posted on Amazon Mechanical Turk to gather data from respondents resident in Canada and United States. However, it was sent via email to respondents resident in Nigeria for participation. The Nigerian group of participants were recruited via email because many of them were not on the Amazon Mechanical Turk platform. In appreciation of the time of participants from Canada and United Sates, each was compensated with US $1.50. However, each participant from Nigeria was compensated with a N200 Nigerian phone credit card. See Figure B.1 and Figure B.2 (in the Appendix) for the collectivist and individualist participants' consent forms, respectively.

5.5.3 Participants

Over 300 participants from Canada/United States and Nigeria took part in the study. Table 5.2 shows the demographic information of the valid participants (n = 256) after data cleaning. Specifically, 189 participants from Canada/United States (individualist culture) and 67 participants from Nigeria (collectivist culture) were validated and employed in carrying out the final data analysis.

Table 5.2: Demographics of participants in the study of users' receptiveness to persuasive strategies

		Number		**Percent**	
Criterion	**Subgroup**	**COL**	**IND**	**COL**	**IND**
Gender	Female	29	82	43.3	43.4
	Male	35	106	52.2	56.1
	Other	3	1	4.5	0.5
Age	18-24	26	29	38.8	15.3
	25-34	29	100	43.3	52.9
	35-44	9	39	13.4	20.6
	45-54	0	15	0.0	7.9
	54+	0	6	0.0	3.2
	Unspecified	3	0	4.5	0.0
Education	Technical/Trade School	1	37	1.5	19.6
	High School	2	34	3.0	18.0
	Bachelor	51	86	76.1	45.5
	Masters	10	26	14.9	13.8
	Doctorate	0	4	0.0	2.1
	Others	3	2	4.5	1.1
Country of Origin	Canada	0	89	0.0	47.1
	United States	0	100	0.0	52.9
	Nigeria	67	0	100.0	0.0
Occupation	Employee	34	110	50.7	58.2
	Employer	5	7	7.5	3.7
	Self-employed	6	38	9.0	20.1
	Student	14	26	20.9	13.8
	Other	8	8	11.9	4.2
Years on the Internet	1-5	9	1	13.4	0.5
	6-10	30	28	44.8	14.8
	11-15	18	39	26.9	20.6
	16-20	7	66	10.4	34.9
	20+	0	55	0.0	29.1
	Unspecified	3	0	4.5	0.0

5.5.4 Measurement Instruments

Two quantitative measures (rating and ranking) and one qualitative measure (open question) were used in the investigation of participants' persuasion profiles. First, the study participants were asked to rate each of the storyboards in terms of *perceived persuasiveness* on a 7-point Likert scale. Second, they were asked to rank all six persuasive features (presented in a randomized list) in terms of the one that would motivate them the most (1) to the one that would motivate them the least (6). (During data analysis, this scale was reversed.) Finally, the participants were asked to provide general comments on the persuasive features illustrated on each storyboard in the light of their ratings.

Rating Measure

Figure 5.2 and Figure 5.3 show the storyboards illustrating Goal-Setting/Self-Monitoring and Social Learning, respectively. In the Goal-Setting/Self-Monitoring storyboard (first screen), the hypothetical user set a goal of 4000 calories for a given day. Later that day (second screen), the user could not meet her goal. Hence, in the third screen, she increased the duration of her exercise to be able to meet her goal the next day.

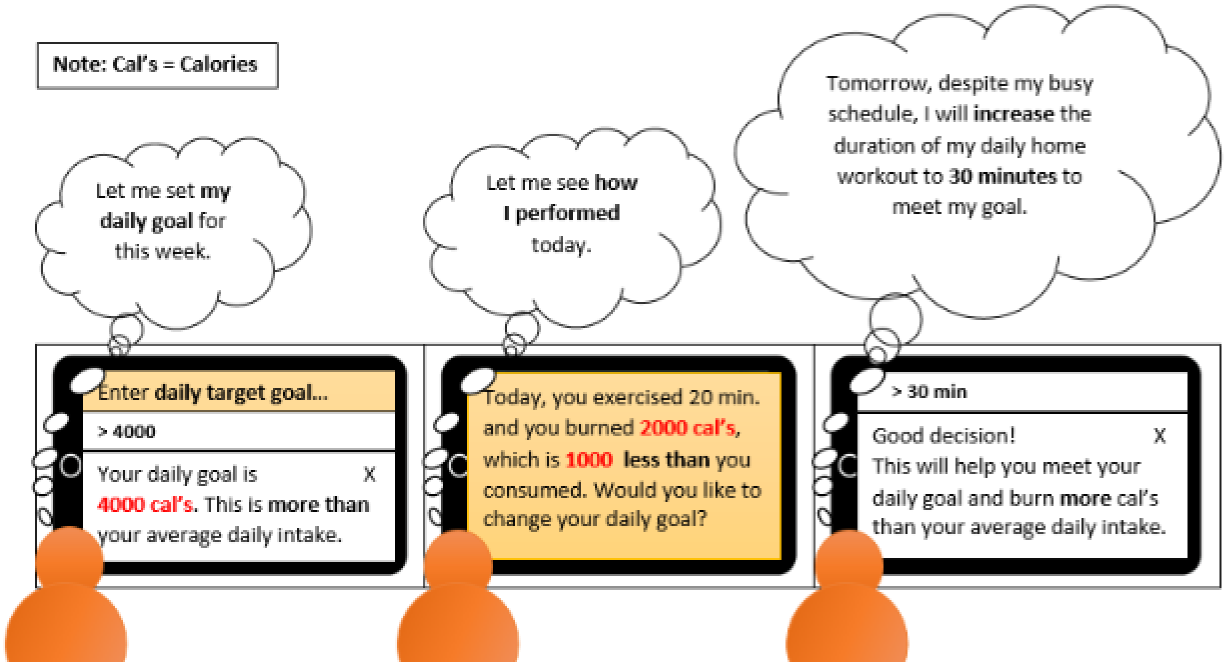

Figure 5.2: Storyboard illustrating Goal-Setting/Self-Monitoring persuasive feature

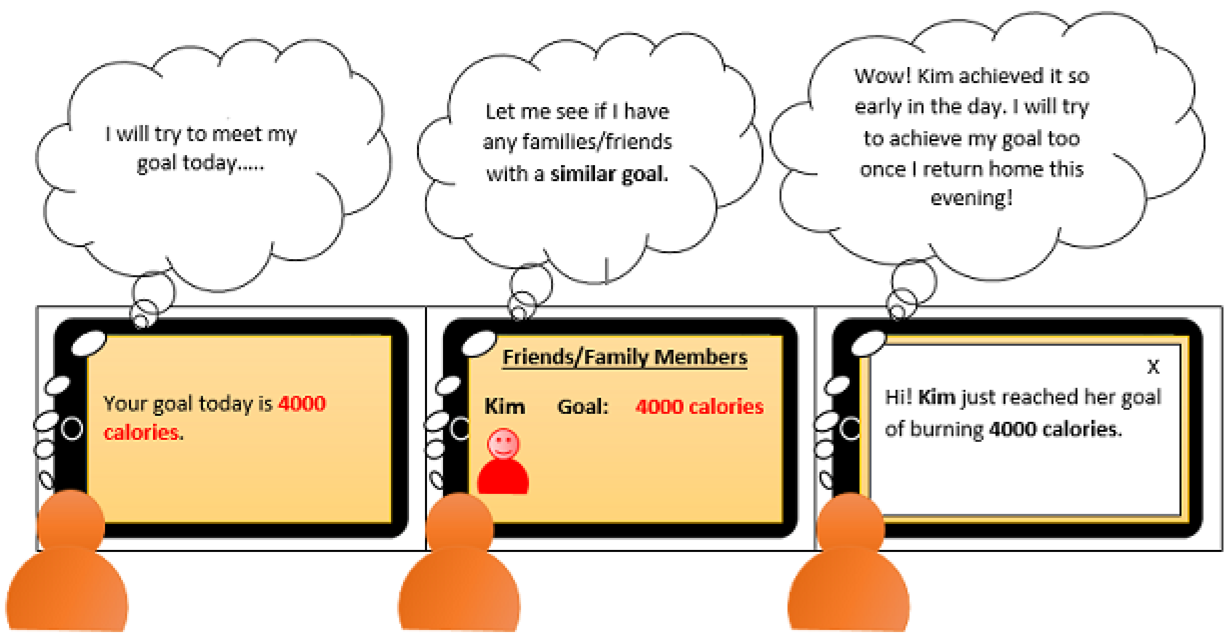

Figure 5.3: Storyboard illustrating Social Learning persuasive feature

Moreover, in the Social Learning storyboard, for example, the hypothetical user, in a collaborative setting, is allowed to view the goal of his friend, Kim, whose goal for the day is 4000 calories (second screen). Once Kim achieved his goal, the user received a notification (third screen). With the aid of the storyboards, I set out to uncover the levels of receptiveness of the target audience to the illustrated persuasive strategies. See Appendix B for the rest of the storyboards. The following question, adapted from the *perceived persuasiveness* scale [109][206], was posed to the participants after viewing each of the six storyboards:

"*Imagine that you are using the Homex App presented in the storyboard above to track your physical activity, to what extent do you agree with the following statements:*"

1. This feature of the app would influence me.

2. This feature of the app would be convincing.

3. This feature of the app would be personally relevant to me.

4. This feature of the app would make me reconsider my physical activity.

The *perceived persuasiveness* scale (shown above) ranged from "Strongly Disagree (1)" to "Strongly Agree (7)." It has been applied in previous studies such as [32]. Prior to answering the above questions, the participants were asked to briefly study each storyboard and choose from a list of options the correct persuasive feature illustrated on the storyboard. This step was intentionally included in the questionnaire to increase the reliability of the responses, i.e., to ensure that the participants understood the storyboard and the persuasive feature illustrated. As a result, in the process of cleaning the data, the participants' responses to each question based on an incorrectly identified persuasive feature were treated as missing data and filled in with the question's mean score based on the correctly identified persuasive feature.

Ranking Measure

In addition to rating the storyboards, the study participants were asked to rank a randomized list of the six persuasive features from 1 (the one that will motivate them the most) to 6 (the one that will motivate them the least). I intentionally included the ranking measure to account for: (1) the effect the user interface (UI) design of the storyboards may have on the *perceived persuasiveness* of the features illustrated on the storyboards; and (2) the possible differences in the levels of criticality of the two types of cultures when evaluating (rating) HCI artifacts. For example, in an empirical study to evaluate the perception of mobile websites, Oyibo et al. [119], found that Canadians are more likely to be critical of the UI design than Nigerians. To account for this potential cultural difference, I asked the study participants to rank the six persuasive features as well: "*Please rank these features, starting with the one you think will help you achieve your exercise goals the most (FIRST) to the least (SIXTH).*" The forced-ranking question was meant to provide additional insight into how the two types of culture compare with respect to the personal and social features in the event that one culture was more likely to rate all of the storyboards favorably than the other.

Qualitative Measure

After the study participants had finished rating the storyboards in terms of the *perceived persuasiveness* of the illustrated features, they were requested to provide comments to justify their ratings. The question read, "*Provide comments about this application feature [persuasive strategy illustrated on the storyboard] to justify your rating here [textbox].*" I chose to include this qualitative measure in the study in order to triangulate the quantitative with the qualitative findings.

5.6 S2a: Investigation of the Persuasion Profile of the Target Audience in the Application Domain and the Moderating Effect of Culture: A Quantitative Approach

In this section and investigation (S2a), I present the quantitative data analysis, results and discussion with regard to the following two subquestions which derive from RQ2.

RQ2a. How do the two types of culture differ in their receptiveness to commonly employed *personal* persuasive strategies (features) in the application domain?

RQ2b. How do the two types of culture differ in their receptiveness to commonly employed *social* persuasive strategies (features) in the application domain?

Thus, this investigation is aimed at uncovering the persuasion profiles of the target audience in the application domain and the moderating effect of culture. This will help to confirm the significant social-cognitive determinants of physical activity in the theory domain. Moreover, it will help to determine the specific persuasive strategies that will be implemented as persuasive features in the actual PHA.

5.6.1 Data Analysis and Results

This section focuses on the reliability analysis for the measurement instruments, the average ratings and rankings of the six persuasive features and the analysis of variance (ANOVA).

Measurement Instrument Reliability

Prior to computing the average score of each persuasive feature (based on the rating and ranking measures) and conducting ANOVA, I conducted a reliability test. The test was aimed to ensure that each persuasive feature was reliably measured by the *perceived persuasiveness* scale. It was based on the McDonald's omega (ω) metric rather than the Cronbach's alpha (α) metric given that the data was not normally distributed as most questionnaire data [190]. The reliability test employed the "ci.reliability" function provided by the "MBESS" library in R [191]. The results of the test showed that all of the six constructs (persuasive features) satisfied the minimum reliability requirement (i.e., $\omega >= 0.7$) [172].

Average Values of Quantitative Measures

This section covers the graphical plots of the culture-specific mean ratings and rankings of the six persuasive features and the result of the two-way ANOVA based on culture and persuasive feature.

Culture-Specific Mean Rating of the Persuasive Features. Figure 5.4 shows the culture-specific mean rating and ranking of the six persuasive features. Based on the rating measure, for the collectivist culture, all of the six persuasive features were rated higher than the neutral value of 4. However, for the individualist culture, only Goal-Setting/Self-Monitoring, Reward and Competition were rated above or approximately the neutral value of 4. Moreover, based on the ranking measure, for the collectivist culture, Goal-Setting/Self-Monitoring, Reward, Social Learning and Cooperation were ranked above or approximately the average value of 3.5. However, for the individualist culture, only Goal-Setting/Self-Monitoring, Reward and Competition were ranked above or approximately the average value of 3.5.

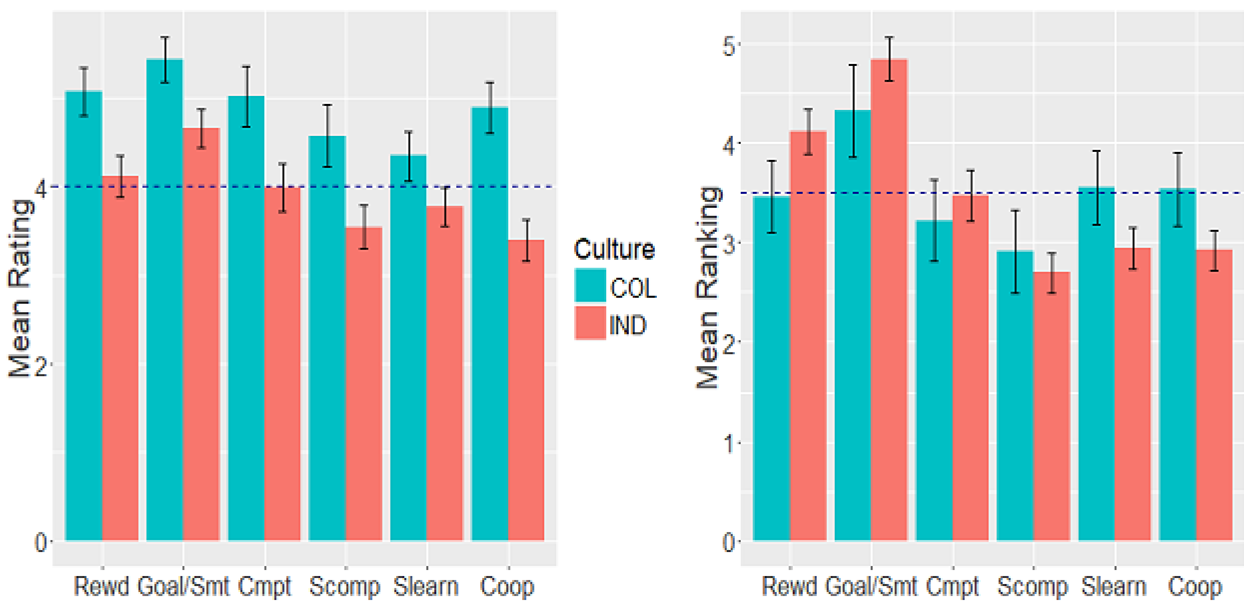

Figure 5.4: Culture-based mean rating (left) and ranking (right) of persuasive features. Vertical bar = 95% confidence interval, crossbar = neutral value on 1-7 rating scale and mean value on 1-6 ranking scale.

Two-Way Analysis of Variance of Quantitative Measures

To uncover how the two cultures differ in their rating and ranking of the six persuasive features, I conducted a non-parametric repeated measure ANOVA based on culture and persuasive feature using the ARTool package in R [75][76][207]. Regarding the rating measure, the result showed that there is a main effect of culture [$F_{1,1524} = 117.42, p < 0.001$, $\eta_p^2 = 0.07$] with a medium effect size, a main effect of persuasive feature [$F_{5,1524} = 19.30, p < 0.001$, $\eta_p^2 = 0.06$] with a medium effect size, and an interaction between culture and persuasive feature [$F_{5,1524} = 2.89, p < 0.05$, $\eta_p^2 = 0.009$] with a near small effect size. According to Cohen [193], $0.01 \leq \eta_p^2 < 0.01$ represents small effect size, $0.06 \leq \eta_p^2 < 0.06$ represents medium effect size, $\eta_p^2 \geq$

0.14 represents large effect size [194]. Regarding the ranking measure, the result showed that there is a main effect of persuasive feature [$F_{5,1524} = 40.53, p < 0.001$, $\eta_p^2 = 0.12$] with a medium effect size and an interaction between culture and persuasive feature [$F_{5,1524} = 6.04, p < 0.001$, $\eta_p^2 = 0.02$] with a small effect size. However, the result showed, there is no main effect of culture [$F_{1,1524} = 0.18, p = n.s$, $\eta_p^2 = 0.00$]. Furthermore, owing to the interaction between culture and persuasive feature with respect to both measures, I conducted between- and within-group analyses. The results are presented in the following subsections.

Culture Effect: Between-Group Comparison. Table 5.3 shows the results of the between-group analysis for the rating and ranking measures. For both measures, there is a significant difference between both cultures in their receptiveness to each of the six persuasive features. First, the result based on the rating measure shows that the collectivist group is significantly more likely to be receptive to all six persuasive features than the individualist group ($p < 0.05$), with the effect size of the mean difference ranging from small (0.02) for Social Learning to large (0.16) for Cooperation. Second, the result based on the ranking measure shows that the individualist group is significantly more likely to be receptive to Goal-Setting/Self-Monitoring ($p = 0.085$ - marginal) and Reward ($p < 0.05$) than the collectivist group, with the effect size of the mean difference for both persuasive features being small. In contrast, the ranking-based result shows that the collectivist group is significantly more likely to be receptive to Social Learning and Cooperation than the individualist group ($p < 0.01$), with the effect size of the mean difference for both persuasive features being small as well.

Table 5.3: Between-group comparison of mean values of persuasive features. $\eta_p^2 = 0.01$: small effect size, $\eta_p^2 = 0.06$: medium effect size, $\eta_p^2 = 0.14$: large effect size [193][195].

	Rating Measure				**Ranking Measure**			
Feature	**COL**	**IND**	***p*-Value**	**η_p^2-Value**	**COL**	**IND**	***p*-Value**	**η_p^2-Value**
REWD	5.07	4.11	0.0002	0.05	3.46	4.12	0.0015	0.04
GOAL/SMT	5.44	4.66	0.0004	0.05	4.32	4.85	0.0850	0.01
CMPT	5.02	3.99	0.0000	0.06	3.22	3.47	0.3335	0.00
SCOMP	4.57	3.55	0.0000	0.07	2.91	2.70	0.5965	0.00
SLEARN	4.35	3.77	0.0234	0.02	3.55	2.94	0.0052	0.03
COOP	4.89	3.39	0.0000	0.16	3.54	2.92	0.0053	0.03

Persuasive Feature Effect: Within-Group Comparison. Table 5.4 and Table 5.5 show the posthoc pairwise-comparison results based on both measures for the collectivist and individualist groups, respectively. The results of the within-group analyses show that there is a significant difference between most of the pairs of persuasive features, particularly within the individualist group. For example, in both culture-based pairwise comparisons (Table 5.4 and Table 5.5), regardless of measure, there is a significant difference between Goal-Setting/Self-Monitoring and the other five persuasive features ($p < 0.05$). The only exception is the pairwise-

Table 5.4: Collectivist pairwise comparisons of persuasive features. M = Mean score of persuasive feature. d = 0.01 : very small effect size, d = 0.20 : small effect size, d = 0.50 : mediun effect size, d = 0.80 : large effect size, d = 1.20 : very large effect size, d = 2.0 : huge effect size [193][195][208].

	Rating				Ranking			
Feature Comparison	**M1**	**M2**	***p*-Value**	***d***	**M1**	**M2**	***p*-Value**	***d***
GOAL/SMT – REWD	5.44	5.07	n.s	0.25	4.32	3.46	0.0328	0.52
GOAL/SMT – CMPT	5.44	5.02	n.s	0.31	4.32	3.22	0.0018	0.67
GOAL/SMT – SLEARN	5.44	4.35	0.0001	1.02	4.32	3.55	0.0768	0.47
GOAL/SMT – SCOMP	5.44	4.57	0.0001	0.80	4.32	2.91	0.0001	0.86
GOAL/SMT – COOP	5.44	4.89	0.0101	0.58	4.32	3.54	0.0684	0.47
REWD – CMPT	5.07	5.02	n.s	0.06	3.46	3.22	n.s	0.15
REWD – SLEARN	5.07	4.35	0.0002	0.77	3.46	3.55	n.s	0.05
REWD – SCOMP	5.07	4.57	0.0176	0.56	3.46	2.91	n.s	0.34
REWD – COOP	5.07	4.89	n.s	0.34	3.46	3.54	n.s	0.05
CMPT – SLEARN	5.02	4.35	0.0007	0.71	3.22	3.55	n.s	0.20
CMPT – SCOMP	5.02	4.57	0.0517	0.49	3.22	2.91	n.s	0.19
CMPT – COOP	5.02	4.89	n.s	0.28	3.22	3.54	n.s	0.19
SLEARN – SCOMP	4.35	4.57	n.s	0.21	3.55	2.91	n.s	0.39
SLEARN – COOP	4.35	4.89	n.s	0.43	3.55	3.54	n.s	0.08
SCOMP – COOP	4.57	4.89	n.s	0.22	2.91	3.54	n.s	0.38

Table 5.5: Individualist pairwise comparisons of persuasive features. M = Mean score of persuasive feature. d = 0.01 : very small effect size, d = 0.20 : small effect size, d = 0.50 : mediun effect size, d = 0.80 : large effect size, d = 1.20 : very large effect size, d = 2.0 : huge effect size [193][195][208].

	Rating				Ranking			
Feature Comparison	**M1**	**M2**	***p*-Value**	***d***	**M1**	**M2**	***p*-Value**	***d***
GOAL/SMT – REWD	4.66	4.11	0.0122	0.34	4.85	4.12	0.0001	0.47
GOAL/SMT – CMPT	4.66	3.99	0.0001	0.46	4.85	3.47	0.0001	0.90
GOAL/SMT – SLEARN	4.66	3.77	0.0001	0.68	4.85	2.94	0.0001	1.24
GOAL/SMT – SCOMP	4.66	3.55	0.0001	0.85	4.85	2.70	0.0001	1.40
GOAL/SMT – COOP	4.66	3.39	0.0001	0.94	4.85	2.92	0.0001	1.26
REWD – CMPT	4.11	3.99	n.s	0.12	4.12	3.47	0.0006	0.42
REWD – SLEARN	4.11	3.77	0.0139	0.34	4.12	2.94	0.0001	0.77
REWD – SCOMP	4.11	3.55	0.0001	0.51	4.12	2.70	0.0001	0.93
REWD – COOP	4.11	3.39	0.0001	0.6	4.12	2.92	0.0001	0.78
CMPT – SLEARN	3.99	3.77	n.s	0.22	3.47	2.94	0.0105	0.35
CMPT – SCOMP	3.99	3.55	0.0022	0.39	3.47	2.70	0.0001	0.50
CMPT – COOP	3.99	3.39	0.0001	0.48	3.47	2.92	0.0066	0.36
SLEARN – SCOMP	3.77	3.55	n.s	0.17	2.94	2.70	n.s	0.16
SLEARN – COOP	3.77	3.39	n.s	0.26	2.94	2.92	n.s	0.01
SCOMP – COOP	3.55	3.39	n.s	0.09	2.70	2.92	n.s	0.15

comparisons related to Competition and Reward for the collectivist group. Moreover, the effect size of the mean difference between each pair of persuasive features ranges from small to very large. Specifically, in the individualist group (Table 5.5), regardless of measure, there is a significant difference between Reward/Competition and Social Learning/Social Comparison/Cooperation ($p < 0.05$), with the effect size of the mean difference between each pair of persuasive features ranging from small to medium. The only exception, in the individualist pairwise differences, is between Competition and Social Learning, which is not statistically significant.

Culture-Specific Persuasion Profiles

Table 5.6 shows the culture-specific persuasion profiles. They are ordered from the most to the least persuasive feature based on the participants' ratings and rankings. Hence, the mean value of each persuasive feature is either significantly or numerically higher than that of the next persuasive feature. The persuasion profiles show that, regardless of measure and culture, the participants are more likely to be receptive to Goal-Setting/Self-Monitoring than the other features. Comparatively, based on the rating measure, the collectivist culture is significantly more likely to be receptive to all of the six persuasive features than the individualist culture. However, based on the ranking measure, the individualist culture is more likely to be receptive to Goal-Setting/Self-Monitoring and Reward than the collectivist culture. In contrast, the collectivist culture is more likely to be receptive to Cooperation and Social Learning than the individualist culture.

Table 5.6: Persuasion profiles based on the perceived persuasiveness of persuasive features. The underline indicates where IND and COL significantly differ (p < 0.05) in each measure, with the bolder feature indicating higher users' receptiveness; "superscript construct[1]" indicates marginal significant difference (p = 0.085) between both cultures regarding Goal-Setting/Self-Monitoring.

Group	Measure	Ordered Persuasive Features based on Perceived Persuasiveness
COL	Rating	<u>**GOAL/SMT**</u>, <u>**REWD**</u>, <u>**CMPT**</u>, <u>**COOP**</u>, <u>**SCOMP**</u>, <u>**SLEARN**</u>
	Ranking	<u>GOAL/SMT[1]</u>, <u>**SLEARN**</u>, <u>**COOP**</u>, <u>REWD</u>, CMPT, SCOMP
IND	Rating	<u>GOAL/SMT</u>, <u>REWD</u>, <u>CMPT</u>, <u>SLEARN</u>, <u>SCOMP</u>, <u>COOP</u>
	Ranking	<u>**GOAL/SMT[1]**</u>, <u>**REWD**</u>, CMPT, <u>SLEARN</u>, <u>COOP</u>, SCOMP

5.6.2 Discussion

I have presented the culture-specific persuasion profiles of the target audience based on six commonly employed persuasive features in PHAs. Specifically, I presented the level of receptiveness of the cultural groups to two personal features (Goal-Setting/Self-Monitoring and Reward) and four social features (Competition, Social Comparison, Social Learning and Cooperation). The ANOVA showed that there is an interaction between culture and persuasive feature based on the ranking measure. Table 5.6 shows the persuasion profiles for the respective cultural groups. The profiles were based on the results of the within- and between-group analyses. In the between-group analysis, nine of the 12 comparisons (six ratings and six rankings) are consistent with expectations and only three were inconsistent. The individualist participants were expected to score higher in the personal features (Goal-Setting/Self-Monitoring and Reward). On the other hand, the collectivist participants were expected to score higher in the social features (Competition, Social Comparison, Social Learning and Cooperation). Though a number of the group differences were not statistically significant, the numerical differences were in the expected directions. Regarding social features, Cooperation and Social Learning were significantly rated and ranked higher by the collectivist group than the individualist group (four consistencies). Social comparison was rated and ranked higher by the collectivist group than the individualist group, though the difference was not statistically significant (two consistencies). Moreover, Competition was significantly rated higher by the collectivist group than the individualist group (one consistency). Though Competition was ranked higher by the individualist group than by the collectivist group (one inconsistency), the difference (0.25) was neither substantial nor significant at $p < 0.05$. Regarding personal features, the individualist group ranked Goal-Setting/Self-Monitoring and Reward marginally and significantly, respectively, higher than the collectivist group as expected (two consistencies). The only unexpected inconsistency, with respect to the personal features, is the rating of Goal-Setting/Self-Monitoring and Reward by the collectivist group higher than that by the individualist group (two inconsistencies).

Users' Receptiveness to Personal Features

Overall, based on the rating and ranking measures, Goal-Setting/Self-Monitoring and Reward turned out to be the most persuasive features, to which participants from both cultures are receptive.

Goal-Setting/Self-Monitoring: Most Persuasive Feature. Overall, irrespective of culture, the participants are more likely to be receptive to Goal-Setting/Self-Monitoring based on the rating and ranking measures. This finding might not be surprising given that a health application such as a fitness app aimed at behavior change might not be considered useful by potential users if it does not have the basic capability of goal-setting and self-monitoring. Specifically, the finding provides empirical evidence for the need for every minimally viable PHA aimed at changing behavior to support Goal-Setting/Self-Monitoring in the least.

In a prior study [209], I argued that every minimally viable health application aimed at motivating behavior change, for it to be effective, must have at least the functionality of goal-setting and self-monitoring, both of which I considered complimentary fundamental features. I considered Goal-Setting and Self-Monitoring complimentary features that must be implemented side by side in a fitness application because it is no use setting goals if the user cannot track his/her behavior towards achieving the set goal and vice versa. This means if a user sets goals, then s/he should be given the opportunity to track his/her progress towards reaching those goals as well. Similarly, if a user is allowed to track his/her behavior, then s/he should be given the opportunity to set goals to achieve the target behavior [209]. For this reason, in the storyboards, I intentionally implemented Goal-Setting/Self-Monitoring as a composite feature because of their complementarity. Thus, when combined with Self-Monitoring, Goal-Setting allows the user to set a target goal and track his/her activities towards reaching the target goal through self-monitoring.

Moreover, the current finding is in line with previous findings in persuasion-profile research based on Cialdini's principles of persuasion. For example, Oyibo et al. [122] found that, among the six Cialdini's [148] principles of persuasion (Commitment, Reciprocity, Authority, Liking, Consensus and Scarcity), Commitment is the most persuasive regardless of culture. To operationalize Commitment, the authors mapped it to Goal-Setting in the PT domain. They explained that Goal-Setting can be likened to making a commitment to a persuasive application to achieve a particular set goal [122]. Research [205][210] has shown that users are more likely to be persuaded to engage in the target behavior if persuasive applications support the making of commitments, i.e., Goal-Setting. Furthermore, Goal-Setting is more likely to be successful if set goals are "SMART," i.e., specific, measurable, attainable, relevant and time-bound [122]. According to [122], by setting "SMART" goals, "*the user is indirectly making a commitment to the persuasive system. As a result, the likelihood of the user performing the target behavior is higher than when no goal is set.*"

Reward: Second Most Persuasive Feature. In the within-group analyses, based on the rating measure, Reward turned out to be the second most persuasive feature after Goal-Setting/Self-Monitoring. In the individualist persuasion profiles, Reward was significantly and/or numerically rated and ranked higher than the other features apart from Goal-Setting/Self-Monitoring as shown in Table 5.4 and Table 5.5. Similarly, in the collectivist persuasion profile, Reward was rated higher than Social Learning and Social Comparison and ranked approximately the average value. These results (based on the rating measure for both cultures and the ranking measure for the individualist culture) suggest that Reward is the second important feature in a PHA to users after Goal-Setting/Self-Monitoring. For the above reason, in a health application aimed at motivating behavior change—basically, a one-size-fits-all application—Reward can be implemented in addition to Goal-Setting/Self-Monitoring to motivate the performance of the target behavior. In particular, Oyibo et al. [122] suggested that one way of making Goal-Setting more effective in changing behavior is by implementing it in concert with Reward. The authors argued that, given that most health benefits are not immediately visible, by providing users incentives-based feedback for achieving their set goals, users are able to visualize the immediate non-health benefit (e.g., points, badges, etc.), which tends to reinforce the performance of the target behavior [103].

Users' Receptiveness to Social Features

The mean ratings of the four social features and the within-group analysis showed that the two cultural groups differ with respect to their receptiveness to the four social features and the pairwise comparisons.

Individualist Social Features. As shown in Figure 5.4, the individualist participants are only likely to be receptive to Competition among the four social features. Their mean rating of the other three features is way below the neutral value of 4. Similarly, their mean ranking of the three social features in question is way below the mean value of 3.5 as well. Moreover, their mean rating of Competiton is significantly higher than their mean ratings of Cooperation and Social Comparison ($p < 0.01$). Similarly, their mean ranking of Competiton is significantly higher than the mean ratings of Cooperation, Social Comparison as well as Social Learning ($p < 0.05$). These findings are an indication that the individualist participants might not be receptive to Social Learning, Social Comparison and Cooperation. Thus, in implementing a social PHA for the individualist culture, Competition should be given priority over the other three social features.

Collectivist Social Features. Based on the rating measure (Figure 5.4), the collectivist participants are likely to be receptive to all four social features as they rated each of them way above the neutral value of 4. Although the pairwise differences are not significant, the ranking measure indicates that the collectivist participants are more likely to be receptive to Cooperation and Social Learning (mean ranking equal to or above the mean value of 3.5) than Competition and Social Comparison (mean ranking less than the mean value of 3.5). Therefore, in implementing a social PHA for the collectivist group, Cooperation and Social Learning should be given priority over Competition and Social Comparison.

5.6.3 Summary of Findings

In this section, I present a summary of the main differences that exist between the two cultural groups based on the rating and ranking measures. Overall, the collectivist culture is likely to be receptive to both personal and social features. However, the individualist culture is only likely to be receptive to personal features (Goal-Setting/Self-Monitoring and Reward) and one social feature (Competition).

Rating-Based Cultural Difference

The two-way ANOVA based on the rating measure showed that there is a main effect of culture, with the collectivist group significantly rating all six persuasive features higher than the individualist group. Research [79] shows that culture influences users' level of criticality in the judgment of HCI artifacts. In the rating of the *perceived persuasiveness* of the storyboards, the study participants must have taken into consideration the UI design of the storyboards (as the qualitative analysis reveals later). As a result, the individualist participants (Canadians/Americans) are more likely to have been critical of the UI design of the storyboards than the collectivist participants (Nigerians). One plausible reason for the higher level of criticality of the individualist culture is that it is more technologically advanced, with its members having a higher mobile Internet experience. In general, research [190] shows that users with higher Internet experience are more likely to be critical of HCI artifacts when evaluating them. In the current investigation, the individualist group had higher Internet experience than the collectivist group, which may account for why it rated the *perceived persuasiveness* of all six storyboards less than the collectivist group. For example, only 37% of the Nigerian subjects (collectivist group) had over 10 years of Internet experience, compared with 85% of the Canadian/American subjects (individualist group). Moreover, 29% of the individualist participants had over 20 years of Internet experience, compared with 0% of the collectivist participants. By accounting for the possible influence of culture in the rating of the *perceived persuasiveness* of the features illustrated on the storyboards, I base the conclusions of the between-group comparisons on the ranking of the persuasive features as presented in the next subsection.

Ranking-Based Cultural Difference

The two-way ANOVA based on the ranking measure showed that there is an interaction between culture and persuasive feature. On one hand, the between-group comparison result (Table 5.3) suggests that the individualist culture is more likely to be receptive to Reward ($p < 0.01$) and Goal-Setting/Self-Monitoring than the collectivist culture ($p = 0.0850$—marginal). On the other hand, the collectivist culture is more likely to be receptive to Cooperation ($p < 0.01$) and Social Learning than the individualist culture ($p < 0.01$). This finding supports the rating-based finding, in which the collectivist culture significantly rated Cooperation ($p < 0.000$) and Social Learning ($p < 0.05$) higher than the individualist culture. Comparatively, based on the rating-based findings, I conclude thus: (1) the individualist culture is more likely to be receptive to personal features than the collectivist culture; and (2) the collectivist culture is more likely to be receptive to social features than the individualist culture. The qualitative analysis will help in confirming or refuting this finding based on the ranking measure.

5.7 S2b: Investigation of the Drivers of the Receptiveness of the Target Audience to Personal Persuasive Features and the Moderating Effect of Culture: A Qualitative Approach

In this section and investigation (S2b), I present the qualitative data analysis, results and discussion with regard to the following subquestion (RQ2a), "*How do the two types of culture differ in their receptiveness to commonly employed personal persuasive strategies (features) in the application domain?*"

Answering the research question using a qualitative approach will help to confirm the quantitative results in S2a and, by extension, the culture-specific significant social-cognitive determinants of physical activity in the theory domain. The personal features of interest include Goal-Setting/Self-Monitoring and Reward.

5.7.1 Data Analysis

The data analysis is based on the open question, "*Provide comments about this application feature [persuasive strategy illustrated on the storyboard] to justify your rating here [textbox].*" A thematic analysis was conducted on the comments provided by the study participants about the Goal-Setting/Self-Monitoring and Reward features. The results of the thematic analysis are organized into two major categories as follows:

1. The reasons why participants from collectivist and individualist cultures are *likely* to be receptive to a given personal persuasive feature (also known as the drivers of the use of a PHA equipped with such a feature); and

2. The reasons why participants from collectivist and individualist cultures are *unlikely* to be receptive to a given personal persuasive feature (also known as the barriers against the use of a PHA equipped with such a feature).

5.7.2 Results Based on Goal-Setting/Self-Monitoring Feature

In this section, I focus on the thematic analysis of participants' comments on the Goal-Setting/Self-Monitoring storyboard to uncover the reasons behind their receptiveness or non-receptiveness to this feature.

Reasons Why Users are Likely to be Receptive to Goal-Setting/Self-Monitoring

The thematic analysis entailed the coding of the participants' comments into various themes. Table 5.7 the different reasons why users in both types of culture are likely to be receptive to the personal feature of Goal-Setting/Self-Monitoring. I regard the six reasons (themes) as the key drivers of the use of a PHA equipped with the Goal-Setting/Self-Monitoring feature by users in collectivist and individualist cultures. These drivers can be regarded as the strengths of Goal-Setting/Self-Monitoring. Specifically, Table 5.7 shows the percentage of participants in each culture that gave favorable comments regarding each driver. Overall, there is a higher percentage of participants in the individualist culture than in the collectivist culture that provided favorable comments on the seven drivers. In total, regarding the six drivers, 28% of the collectivist participants and 48% of the individualist participants provided favorable comments on Goal-Setting/Self-Monitoring.

Reasons Why Users are Unlikely to be Receptive to Goal-Setting/Self-Monitoring

Table 5.8 shows the different reasons why users from both cultures are unlikely to be receptive to Goal-Setting/Self-Monitoring. I regard the six reasons (themes) as the key barriers against the use of a PHA equipped with the Goal-Setting/Self-Monitoring feature by users from both cultures. These drivers can be regarded as the weaknesses or disadvantages of Goal-Setting/Self-Monitoring. Table 5.8 shows the percentage of participants in each culture that gave unfavorable comments regarding each driver. Overall, there is a higher percentage of participants in the individualist culture than in the collectivist culture that provided unfavorable comments regarding the six drivers. In total, 9% of the individualist participants, compared with 4% of the collectivist participants, provided unfavorable comments on Goal-Setting/Self-Monitoring.

5.7.3 Result Based on Reward Feature

In this section, I focus on the thematic analysis of participants' comments on the storyboard illustrating Reward to uncover the reasons behind their receptiveness or non-receptiveness to this feature.

Table 5.7: Reasons why collectivist and individualist users are likely to be receptive to Goal-Setting/Self-Monitoring.

Themes related to Goal-Setting/Self-Monitoring with examples of participants' comments	**COL**	**IND**
GS1. Helps and motivates people to engage in exercise behavior. - "***This will help in motivating me as i complete each daily goal***" [P203] – COL. - "*This feature will definitely* ***change my attitude to physical activities***" [P205] – COL. - "***whenever I set goals I try to accomplish them, this app feature will motivate me***" [P245] – COL. - "*Competition and* ***looking to beat my own goals would give me some motivation and encouragement***" [P177] – IND. - "***I would be motivated to use it and keep progress of my weight loss***" [P16] – IND. - "*I feel* ***the apps features would influence and motivate me to make an effort***" [P27] – IND.	22%	22%
GS2. Helps people to set and track health goals and progress. - "*with the help of the app i will be able to improve my duration for workout and* ***set a goal***" [P192] – COL. - "***This will help me keep track*** *of my physical activities*" [P204] – COL. - "*I like to* ***set goals*** *this would allow me to do so*" [P131] – IND. - "***I like setting myself goals and check how well I meet them****. It looks serious*" [P137] – IND. - "*I like the idea because****it clearly tracks your calories*** *which I usually wouldn't consider while doing exercise*" [P56] – IND. - "***It helps to track my goals*** *and guide me in the right direction. I also like the positive reinforcement given*" [P10] – IND.	6%	11%
GS3. Provides visual feedback that motivates people to reach their goals. - "***Visuals are motivating when it comes to goals***" [P130] – IND. - "*It gives you* ***a visual of your progress*** *which is more motivating*" [P136] – IND. - "***Having the numbers staring back at you*** *can be very motivating*" [P150] – IND. - "*for me being able to track and* ***look back at goals ive accomplished helps***" [P158] – IND.	0%	6%
GS4. Helps people to adjust their exercise behavior to reach their goals. - "*I am also counting calories so it woud be helpful to know how many calories i was burning and* ***adjust activity accordingly***" [P40] – IND. - "*The app would convince me to follow it and* ***adjust my routine accordingly to get the best results***" [P53] – IND. - "*The storyboard scenario makes it seem that* ***the app will help me adjust my goals and behaviours in order to reach my end goals***" [P139] – IND.	0%	4%
GS5. Helps to keep people focused on their plans and health goals. - "*This feature would* ***help me stay focused on my exercise and goals***" [P9] – IND. - "*Goal setting with guidance* ***helps me stick to my plans***" [P107] – IND. - "*I think it would* ***help me stay on track with my health goals***" [P9] – IND. - "*I think it would* ***help me stay on track with my health goals***" [P9] – IND.	0%	3%
GS6. Makes people accountable. - "*This would* ***help me stay accountable***" [P34] – IND. - "*This feature would make me feel like I was in control of the outcomes I received and that* ***I was accountable so I would make sure to meet my goals***" [P42] – IND. - "***It would help with goals and accountability***" [P7] – IND.	0%	2%
Total	28%	48%

Table 5.8: Reasons why collectivist and individualist users are unlikely to be receptive to Goal-Setting/Self-Monitoring

Themes related to Goal-Setting/Self-Monitoring with examples of participants' comments	COL	IND
GW1. Goal-Setting/Self-Monitoring may need to be complemented with other features. - "***Would need more information about suggestions the app gives*** *to form a conclusion on this*" [P23] – IND. - "*I think* ***any additional information and suggestions are useful***" [P68] – IND. - "*I think* ***goal recommendations are necessary*** *burning 4000 calories in one day isn't realistic for most people*" [P105] – IND. - "***It's very easy to set goals and just ignore them***" [P120] – IND. - "*While its great to see a number I think that* ***there needs to be more motivation***" [P121] – IND. - "***it's a limited scope (beginning and basic fitness) app.*** *While it's great that these exist, the market is saturated into lunacy and if I were in a place to use one, I don't see why i would be more drawn to this then any others*" [P27] – IND. - "*Goal setting is important part of the process of creating habits but* ***I would want something more detailed for monitoring progress*** *than just calories or time such as running speed or weight lifted*" [P111] – IND.	0%	3%
GW2. Users do not have interest in monitoring the amount of calories they burn. - "***I'm not really motivated by calorie-counting.*** *More interested in building strength.*" [P3] – IND. - "*It is a great feature but* ***I personally do not pay attention to calories***" [P21] – IND. - "*I don't really exercise to burn specific amounts of calories because* ***I don't count calories really.***" [P44] – IND. - "***I do not base my physical activity on calories***" [P167] – IND. - "***I don't like the idea of talking about calories*** *in an exercise app*" [P186] – IND. - "***I don't count calories because I used to have disordered eating patterns*** *and it is unhealthy for me to do so*" [P12] – IND.	0%	3%
GW3. It takes time and effort to enter goals into the fitness application regularly. - "***I don't know how the app will get the details*** *of i don't give it*" [P254] – COL. - "*Seems like a good thing to do, but* ***I think I would just skip the step if I had to change it daily***" [P116] – IND. - "***Would require far too much time to input accurately***" [P181] – IND.	2%	1%
GW4. Users are demotivated by inability to achieve set goals. - "***Not meeting up with set goals discourages me*** *from continuing. So, it might slightly help me*" [P198] – COL. - "***I just don't think I could live up to the goals and that would depress me***" [P129] – IND.	2%	1%
GW5. Users are self-motivated so they do not require an exercise-tracking app. - "***I don't need to use an app*** *to set goals*" [P29] – IND. - "***I don't have any problems motivating myself.*** *Therefore I don't believe this app would change my habits much*" [P163] – IND.	0%	1%
Total	4%	9%

Table 5.9: Reasons why collectivist and individualist users are likely to be receptive to Reward

Themes related to Reward with examples of participants' comments	**COL**	**IND**
RS1. Reward encourages and motivates people to achieve health goals. - *Rewards **make me want to do more***” [P203] – COL. - *Rewards will **change my attitudes***” [P204] – COL. - ***I put in extra effort to anything I know i will be rewarded for***” [P211] – COL. - *An application that provide reward to user **encourage us to go more***” [P217] – COL. - ***Seeing the points for reward, I might want to do better**.*” [P219] – COL. - *As much as Progress and improvement is important, **reward fosters more work***” [P220] – COL. - ***The reward for hardwork makes you want to do more** hence it would keep me addicted*” [P222] – COL. - ***With the bonus available it will make you exercise the more***” [P224] – COL. - ***I am more motivated to exercise when there is a reward***” [P103] – IND. - *I think it is fun and **motivating to offer reward points** for meeting my goal. I will feel much more likely to workout if I am rewarded for it*” [P26] – IND. - ***I would want to reach my goals and get rewarded***” [P34] – IND. - ***I love being rewarded!** This would **definitely influence me!***” [P35] – IND. - *This feature **would push me to meet my weekly goals***” [P39] – IND. - *Reward systems will **help me get motivated***” [P28] – IND. - *I like the idea of working towards a goal. **It would give me more motivation***” [P36] – IND. - *I know it is silly but **virtual rewards are motivating in real life***” [P107] – IND. - ***Stronger desire to reach goals if there is a reward** for doing so*” [P160] – IND. - *I think this **might help to influence me a little more since it has incentives***” [P18] – IND. - *Rewarding my progress could **influence me to work a little harder** to meet goals*” [P137] – IND. - *Any type of **reward would be a motivator to exercise more***” [P68] – IND. - *This would appeal to me because it would **create more motivation***” [P126] – IND.	36%	21%
RS2. Users like reward and enjoy getting rewarded for achieving their goals. - ***I like rewards***” [P193] – COL. - ***I would like to earn such***” [P218] – COL. - ***People like rewards even if they are just virtual points** with no real world value*” [P120] – IND. - ***I like getting rewarded for hitting milestones***” [P32] – IND. - ***I would want to reach my goals** and **get rewarded***” [P34] – IND. - ***I enjoy getting rewarded** for the effort I put in*” [P116] – IND. - ***I like gratification***” [P128] – IND. - ***i simply like achievements / trophies***” [P122] – IND.	4%	11%
RS3. Reward gives users something to strive for and positively reinforces the target behavior. - ***I like something to strive for** so with rewards it will compel me to do better*” [P61] – IND. - *It would **give me something to look forward to** for meeting my goals*” [P137] – IND. - *Rewards **make people more set on accomplishing something***” [P136] – IND. - *The **positive reinforcement** would be important*” [P62] – IND. - *I like the **positive re-enforcement***” [P59] – IND.	0%	3%
Total	40%	35%

Table 5.10: Reasons why collectivist and individualist users are unlikely to be receptive to Reward

Themes related to Reward with examples of participants' comments	COL	IND
RW1. Virtual rewards are not tangible or convertible to real-life things of value (e.g., money). - ***Tangible reward might make a difference***" [P205] – IND. - ***It depends on what i can use the bonuses acquired for though***" [P54] – COL. - ***Rewards points that are useable would be a good motivator for me to consider re-use***" [P195] – COL. - *virtual rewards are OK* ***but not really tangible***" [P7] – IND. - *I feel that* ***I would rather have a physical reward system***" [PI7] – IND. - ***The points are worthless*** *to me* ***unless they can be exchanged for real world goodies***" [P49] – IND. - ***If those points can be used to redeem physical items*** *then they will be more convincing to me otherwise they are pointless to me*" [P50] – IND. - ***theres no indication on what the points can be redeemed for***" [P52] – IND. - ***Without knowing what I can do with the points, I see no value in it***" [P129] – IND. - ***Don't care to get useless points****, unless there is some real reward to be gained*" [P140] – IND.	9%	15%
RW2. User do not find virtual reward motivating or helpful. - ***Reward systems do not encourage*** *me for my well being*" [P202] – COL. - ***I appreciate the postivity but don't find it particularly motivating***" [P14] – IND. - ***Getting points as a reward would not motivate me***" [P30] – IND. - *Where did these points come from* ***What do they represent Not helpful***" [P38] – IND. - ***i would probabaly not be that motivated about rewards***" [P45] – IND. - ***i dont think earning points*** *will help me*" [P118] – IND.	2%	7%
RW3. Users do not like, care about or need reward (to engage in exercise behavior). - ***i do not care that much about points***" [P119] – IND. - ***Not interested in recieving bonuses***" [P137] – IND. - ***I do not care for points but rather actual information***" [P144] – IND. - ***i dont care about fake points***" [P158] – IND. - ***not interested in points as a way of monitoring success****, translate it into showing results physically*" [P165] – IND. - ***I don't need rewards to perform****. Though I do like the encouragement!*" [P10] – IND.	0%	8%
RW4. Physical health benefit (not virtual) is the ultimate reward for exercise. - ***Reward features don't really interest me at all.*** *I'm* ***more focused on data and physical results*** *of my workout than gaining points or a score. It just isn't my kind of thing, sorry*" [P25] – IND. - ***i dont like the reward system*** *as this is only to make u feeling that u have accomplish something that give u reward base on that.* ***the real reward is ur body getting fit***" [P2] – IND. - ***What will I do with these points? I'm more interested in inches and pounds*** *as well as greater endurance and strength, not brownie points*" [P20] – IND. - ***Not interested in a point system*** *that means absolutely nothing to my overall health*" [P23] – IND. - ***I don't think that bonus points would really affect me*** *because* ***I work out for the enjoyment and strength that I gain***" [P44] – IND. - ***For me, losing weight is the reward for me****, I don't need bonus points to do it.* ***Unless they could be used for something relevant to me***" [P161] – IND.	0%	5%
Total	11%	35%

Reasons Why Users are Likely to be Receptive to Reward

Table 5.9 shows the different reasons why users in both types of culture are likely to be receptive to the personal feature of Reward. I regard the six reasons (themes) as the key drivers of the use of a PHA equipped with the Reward feature by users in collectivist and individualist cultures. These drivers can be regarded as the strengths of Reward. Specifically, Table 5.9 shows the percentage of participants in each culture that gave favorable comments regarding each driver. Overall, there is a higher percentage of participants in the collectivist culture (40%) than in the individualist culture (35%) that provided favorable comments related to the three drivers, although the difference is not very large (5%).

Reasons Why Users are Unlikely to be Receptive to Reward

Table 5.10 shows the different reasons why users in both types of culture are unlikely to be receptive to the personal feature of Reward. I regard the six reasons (themes) as the key barriers against the use of a PHA equipped with the Reward feature by users in collectivist and individualist cultures. These drivers can be regarded as the weaknesses of Reward. Specifically, Table 5.10 shows the percentage of participants in each culture that gave unfavorable comments regarding each driver. Overall, there is a higher percentage of participants in the collectivist culture (35%) than in the individualist culture (11%) that provided unfavorable comments related to the four barriers against the use of a PHA.

5.7.4 Discussion

In this section, I discuss each of the drivers of users' receptiveness and non-receptiveness to the Goal-Setting/Self-Monitoring and Rewards features in a PHA and provide comments from the participants in each culture as evidence to support each driver.

Reasons Why Goal-Setting/Self-Monitoring Motivates Users

In this subsection, I discuss the main reasons why users of a PHA are likely to be receptive to the Goal-Setting/Self-Monitoring feature in both types of culture by drawing on samples of participants' comments.

Goal-Setting/Self-Monitoring helps and motivates people to engage in the target behavior (GS1). The first reason why participants are likely to be receptive to Goal-Setting/Self-Monitoring is that it helps and motivates users to engage in exercise behavior. This theme resonates with 22% of the participants in each culture as shown in Table 5.7. Specifically, Goal-Setting/Self-Monitoring makes people put more efforts and be motivated to achieve their exercise goals. For example, P27 (an individualist participant) commented that "*I feel* ***the apps features would influence and motivate me to make an effort.***" Similarly, P203 (a collectivist participant) commented that "*This will* ***help in motivating me*** *as i complete each daily.*" In particular, P177 commented that Goal-Setting/Self-Monitoring encourages and motivates him to compete with himself. In his own words, "*Competition and* ***looking to beat my own goals***

would give me some motivation and encouragement." Moreover, P204 and P205 commented that Goal-Setting/Self-Monitoring influences their attitudes towards physical activity. P204 said that "*Goal Setting will* ***affect my attitude towards physical activity***," and P205 said that "*This feature* ***will definitely change my attitude to physical activities.***"

Goal-Setting/Self-Monitoring helps people to set and track health goals and progress (GS2). The second reason why participants may be receptive to Goal-Setting/Self-Monitoring is that it helps them to set and track their goals and progress, which enables them to realize their goals. This theme resonates more with the individualist participants (11%) than the collectivist participants (6%) as shown in Table 5.7. For example, P192 (a collectivist participant) commented that "*with the help of the app* ***i will be able to improve my duration for workout and set a goal.***" Similarly, P2 (an individualist participant) commented that "*this feature will* ***let me keep track of my process [progress]*** *that i have made today and* ***how much calories i have burn.*** *so it is a good feature.*" Moreover, P10 believed that Goal-Setting/Self-Monitoring will guide her in the right direction. She commented that Goal-Setting/Self-Monitoring "***helps to track my goals and guide me in the right direction.***"

Goal-Setting/Self-Monitoring provides visual feedback that motivates people to reach their goals (GS3). The third reason why participants may be receptive to Goal-Setting/Self-Monitoring is that it provides visual feedback that motivates people to strive towards reaching their goals. More or less, by seeing the numbers, goals, results and progression, people are motivated to attain their ultimate goal. In particular, this theme resonates only with the individualist participants (6%) as shown in Table 5.7. For example, P150 commented, "***Having the numbers staring back at you can be very motivating.***" For P179, by seeing his result and progress every day, he is motivated to set higher goals. This is evident in his comment, "*I think it is good to* ***see results and progression on a daily basis to set new and higher goals.***" Finally, for P56, "*Being able to* **see the calories on screen** *that I want to lose will really motivate me to keep going.*"

Goal-Setting/Self-Monitoring helps people to adjust their exercise behavior to reach their goals (GS4). The fourth reason why participants may be receptive to Goal-Setting/Self-Monitoring is that it helps them to regulate their exercise behavior towards achieving their goals. This theme resonates only with the individualist participants (4%) as shown in Table 5.7. For example, P139 commented that "***the app will help me adjust my goals and behaviours in order to reach my end goals.***" Furthermore, P146 commented that "***This gives me time to adjust my exercise routine or diet to reach my goal.***"

Goal-Setting/Self-Monitoring helps to keep people focused on their plans and health goals (GS5). The fifth reason why participants may be receptive to Goal-Setting/Self-Monitoring is that it helps them to be focused on their plans and health goals. This theme resonates only with the individualist participants (3%) as shown in Table 5.7. For example, P9 commented that "*This feature* ***would help me stay focused on my exercise and goals.***" Furthermore, P107 believed that, with guidance, Goal-Setting/Self-Monitoring will help her focus on her plans. This is evident in her comment, "*Goal setting with* *guidance* ***helps me stick to my plans.***" Finally, P48 believed that Goal-Setting/Self-Monitoring "***would encourage me to stay on the right path and possibly exceed my exercise goals.***"

Goal-Setting/Self-Monitoring makes people accountable (GS6). The sixth reason why participants may be receptive to Goal-Setting/Self-Monitoring is that it makes them to be accountable. Again, this theme resonates only with the individualist participants (3%) as shown in Table 5.7. For example, P42 commented that "***This feature would make me feel like I was in control of the outcomes I received and that I was accountable*** *so I would make sure to meet my goals.*" Furthermore, for P34, Goal-Setting/Self-Monitoring "***would help me stay accountable.***"

Reasons Why Goal-Setting/Self-Monitoring may Demotivate Users

In this subsection, I discuss the reasons why users of a PHA are unlikely to be receptive to the Goal-Setting/Self-Monitoring feature in both types of culture using typical examples of participant's comments to support each reason.

Goal-Setting/Self-Monitoring may need to be complemented by other features (GW1). The first reason why participants may not be receptive to Goal-Setting/Self-Monitoring is that they think it is not sufficient to foster behavior change; thus, it needs to be complemented with other features such as notifications, reminders, exercise suggestions, exercise recommendations, etc. In particular, this theme resonates with the individualist participants (3%) as shown in Table 5.8. For example, P120 remarked that "***It's very easy to set goals and just ignore them***," suggesting that he might need supportive features such as reminder/notification on when to perform exercise. P23, P68 and P105 would like the app to have the ability to make exercise suggestions and/or recommendations. For example, P68 commented that "***I think any additional information and suggestions are useful.***" Furthermore, for P105, "***I think goal recommendations are necessary*** *burning 4000 calories in one day isn't realistic for most people.*" Some of these persuasive features (e.g., Reminder/Notification, Suggestion/Recommendation, etc.) were requested by some of the participants (especially the collectivist participants) when they were asked in the study, prior to seeing the storyboards on the persuasive features, what key features they cared about.

Users do not have interest in monitoring the amount of calories they burn (GW2). The second reason why participants may not be receptive to Goal-Setting/Self-Monitoring is that they do not care about tracking the amount of calories they burn over time. This theme is particularly expressed by the individualist participants (3%) as shown in Table GW. For example, P44 commented that "***I don't really exercise to burn specific amounts of calories because I don't count calories really.***" Similarly, P21 remarked that "*It is a great feature but* ***I personally do not pay attention to calories.***" This particular group of participants are what Stibe [211] regarded as self-driven people. According to the author, self-contained people have relatively high levels of motivation and can achieve anything that they set out to do. For this reason, this group of people are not looking for additional sources of motivation and/or encouragement. Thus, persuasive technologies (in this case, fitness app) may not be useful or necessary for this group of people.

It takes time and effort to enter goals into the fitness application regularly (GW3). The third reason why participants may not be receptive to Goal-Setting/Self-Monitoring is that they do not have or want to take the time to enter their goals into the fitness application. In other words, they say it takes time and effort set their goal using the means provided by the application, e.g., entering their goal (e.g., calories they intend to burn) into the app). This concern was raised by one collectivist participant (approximately 2%) and two individualist participants (approximately 2%). Specifically, P254 (a collectivist participant) commented that "***I don't know how the app will get the details*** *of i don't give it.*" Similarly, P116 (an individualist participant) commented that "*[s]eems like a good thing to do, but* ***I think I would just skip the step if I had to change it daily***," referring to goal-setting. To crown it all, P181 categorically said that goals "***[w]ould require far too much time to input accurately.***"

Users are demotivated by the inability to achieve set goals (GW4). The fourth reason why participants may not be receptive to Goal-Setting/Self-Monitoring is that not being able to meet their goal may demotivate or discourage them from exercising. This concern resonates with at least one participant in each culture. P198 (a collectivist participant) commented, "***Not meeting up with set goals discourages me*** *from continuing. So, it might slightly help me.*" Similarly, P129 (an individualist participant) commented, "***I just don't think I could live up to the goals and that would depress me.***"

Users are self-motivated so they do not require an exercise-tracking app (GW5). The fifth reason why participants may not be receptive to Goal-Setting/Self-Monitoring is that they are self-motivated and, as such do not need a fitness app. This theme is only expressed by 1% of the individualist participants as shown in Table GW. For example, P21 commented that "***I don't have any problems motivating myself***. *Therefore I don't believe this app would change my habits much.*" Similarly, P29 remarked that "***I don't need to use an app to set goals.***" This particular group of participants are what Stibe [211] regarded as self-contained people. According to the author, self-contained people are not open to changing anything in them (in this case, using an app to motivate behavior change), as they are "*fully satisfied with who they are and what they do on daily basis*" (p. 273) [211]. For this reason, according to the author, many persuasive interventions aimed at changing behavior might fail to influence this group of people.

Reasons Why Reward Motivates Users

In this subsection, I discuss the main reasons why users of a PHA are likely to be receptive to the Reward feature in both types of culture by drawing on samples of participants' comments to support each reason.

RS1. Reward encourages and motivates people to achieve their health goals. The first reason why participants may be receptive to Reward is that it encourages and motivates them to work harder towards achieving their health goals. This theme resonates more with the collectivist participants (36%) than the individualist participants (21%). Specifically, Reward pushes people to put more (extra) efforts towards achieving their goals, even though it is virtual. For example, P107 (an individualist participant) commented that "*I know it is silly but **virtual rewards are motivating in real life.***" Moreover, P211 (a collectivist participant) commented that "***I put in extra effort to anything I know i will be rewarded for.***" Similarly, P39 (an individualist participant) commented that "*This feature **would push me to meet my weekly goals.***" In particular, P26 thought that "***it is fun and motivating to offer reward points** for meeting my goal.*" He added, "*I will feel much **more likely to workout if I am rewarded for it.***" Finally, P160 remarked that he felt a "***Stronger desire to reach goals if there is a reward** for doing so.*"

RS2. Users like reward and enjoy getting rewarded for achieving their goals. The second reason why participants may be receptive to Reward is that they like and enjoy receiving rewards for achieving their goals, even though such incentives are virtual and have not real-life value. This theme resonates more with the individualist participants (11%) than the collectivist participants (4%) as shown in Table 6.8. For example, P120 (an individualist participant) commented that "***People like rewards even if they are just virtual points** with no real world value.*" Similarly, P215 (a collectivist participant) commented, simply, "***I like being appreciated.***" Moreover, in terms of enjoyment, P53 (an individualist participant) commented that "***I would enjoy getting rewards** when meeting my goals and the app would be relevant in this way.*"

RS3. Reward gives users something to strive for and positively reinforces target behavior. The third reason why participants may be receptive to Reward is that it provides people with something to reach and/or strive for and reinforces the target behavior. This theme resonates only with the individualist participants (3%) (see Table 6.8). For example, P61 commented, "*I like **something to strive for** so with rewards it will compel me to do better.*" Similarly, P137 commented, "*It would **give me something to look forward to** for meeting my goals.*" Finally, in terms of reinforcing the target behavior, P59 commented, "*I like the **positive re-enforcement**,*" and P62 remarked, "*The **positive reinforcement** would be important.*"

Reasons Why Reward may Demotivate Users

In this subsection, I discuss the reasons why users of a PHA are unlikely to be receptive to the Reward feature aimed at motivating behavior change in both types of culture using typical examples of participant's comments to support each reason.

RW1. Virtual rewards are not tangible or convertible to real-life things of value. The first reason why participants may not be receptive to the Reward feature is that the offered rewards are only virtual and/or cannot be exchanged for tangible things (e.g., money) that have value in the real world. This theme is more evident in the comments provided by the individualist participants (15%) than by the collectivist participants (9%) as shown in Table 5.10. For example, in the collectivist group, P205 remarked that "***Tangible reward might make a difference***," and P253 commented that "***If the points could be used then that reward would be worth it.***" Similar sentiments are expressed in the individualist culture as well. Specifically, they considered virtual rewards as "worthless," "pointless," and "useless" if they cannot be redeemed for real-life things of value. For example, P49 commented that "***The points are worthless to me unless they can be exchanged for real world goodies.***" Similarly, P50 remarked, "***If those points can be used to redeem physical items*** *then they will be more convincing to me otherwise they are pointless to me.*" One plausible explanation for why this group of individualist participants are so concerned about physical (tangible) rewards is that they are used to this kind of gamification system in the real world, especially in the grocery stores where they get loyalty reward points for their patronage. For example, in Canada and United States, when people earn virtual points for the items they buy at grocery stores (such as Walmart, Superstore, Giant Eagle, etc.), eventually, the cumulative points are converted to tangible items such as money, which they could use to purchase more items, gas, etc. As such, we see more individualist participants being more concerned and blunt about physical rewards, with participants such as P140 saying, "***Don't care to get useless points****, unless there is some real reward to be gained.*" Besides, participants in the individualist culture are also used to getting physical rewards (loyalty reward points) in fitness applications as well. For example, in Canada, the defunct mobile app, Carrot Rewards, deployed in three Canadian provinces and one territory between 2016 and 2019, provided physical rewards, in loyalty programs such as Aeroplan Miles, Petro-Points, etc., to users (in exchange for earned virtual points) for tracking their step counts and completing health-based questionnaires [147].

RW2. User do not find virtual reward motivating or helpful. The second reason why participants may not be receptive to the Reward feature is that they do not find the virtual points helpful or motivating to engage in exercise behavior. This theme is more evident in the comments provided by the individualist participants (7%) than by the collectivist participants (2%) as shown in Table 5.10. For example, in the collectivist group, P202 commented that "***Reward systems do not encourage me*** *for my well being.*" Similarly, in the individualist group, P30 commented that "***Getting points as a reward would not motivate me.***" The reason why this group of participants, especially the individualist participants, are not motivated by virtual reward may not be far-fetched. Among other things, it is due the virtual points not having any physical significance or value, as we saw in RW1 and evident in P38's comment, "*Where did these points come from[?]****What do they represent[?] Not helpful.***"

RW3. Users do not like, care about or need reward to engage in exercise behavior. The third reason why participants may not be receptive to the Reward feature is that they do not like or care about rewards as an incentive to engage in exercise behavior. This theme is only evident in the comments provided by the individualist participants (8%) (Table 5.10). For instance, P119 commented that "***i do not care that much about points.***" Similarly, in the individualist group, P30 commented that "***Not interested in rec[ei]ving bonuses.***" Partly the reason they do not care about reward is explained in RW1 (virtual points do not have physical value). This is evident in P158's comment, "***i don[']t care about fake points.***" The other reason for the "I don't care" attitude expressed by this group of participants is that they care about the physical benefits of exercise rather than the external (virtual) reward, as evident in the comments in RW4.

RW4. Physical health benefit (not virtual) is the ultimate reward for exercise. The fourth reason why participants may not be receptive to the Reward feature is that they do care about the health benefits of exercise (e.g., enjoyment, weight loss, fitness, physical strength, health and wellbeing) rather than the external (virtual) reward. This theme is particularly evident in the comments provided by the individualist participants (5%) as shown in Table 5.10. For instance, P25 commented that "***Reward features don't really interest me at all. I'm more focused on data and physical results of my workout*** *than gaining points or a score.*" Similarly, P2 commented that "***[I] don[']t like the reward system*** *as this is only to make [yo]u feeling that [yo]u have accomplish[ed] something that give[s] [yo]u reward base on that.* ***[T]he real reward is [yo]ur body getting fit.***" Moreover, despite the fact this group of participants think that physical activity should be done for the health benefit and not virtual reward offered by fitness applications, some of them may still be motivated to exercise if the virtual points can be converted into things of real value. This is evident in P161's comment, "*For me,* ***losing weight is the reward for me,*** *I don't need bonus points to do it.* ***Unless they could be used for something relevant to me.***"

5.7.5 Summary of Findings

Table 5.11 shows the overall percentage of favorable comments in each culture with respect to both personal features. It is calculated by deducting the percentage of participants in each culture that made unfavorable comments on each of the features from percentage of participants that made favorable comments.

Table 5.11: Overall percentage of favorable participants' comments on each personal feature

	GOAL/SMT		**REWD**	
	COL	**IND**	**COL**	**IND**
% of favorable comments	28%	48%	40%	35%
% of unfavorable comments	4%	9%	11%	35%
Overall % of favorable comments	24%	39%	29%	0%

In total, 28% of the collectivist participants and 48% of the individualist participants provided favorable comments related to the six drivers of the use of a PHA equipped with Goal-Setting/Self-Monitoring. On the other hand, 4% of the collectivist participants and 9% of the individualist participants provided unfavorable comments related to the five barriers against the use of a PHA equipped with Goal-Setting/Self-Monitoring. Overall, the individualist participants (+39%) are more positively disposed towards Goal-Setting/Self-Monitoring than the collectivist participants (+24%). This indicates Goal-Setting/Self-Monitoring, regardless of culture, is a motivating feature in a PHA, especially among members of the individualist culture. Moreover, as shown in Table 5.11, there is a higher percentage of participants in the collectivist culture (40%) than in the individualist culture (35%) that provided favorable comments on the Reward feature, though the difference is not very large (5%). On the other hand, 11% of the collectivist participants and 35% of the individualist participants provided unfavorable comments related to the four barriers against the use of a

PHA equipped with Reward. Overall, based on the qualitative measure, 29% of the collectivist participants provided favorable comments on Reward, compared with 0% of individualist participants. This indicates that Reward is more likely to motivate collectivist users than individualist users.

5.8 Personal Persuasive Features: Triangulation of Quantitative Findings from S2a and Qualitative Findings from S2b

This section focuses on the triangulation of the qualitative and quantitative findings with respect to the target audience's receptiveness to Goal-Setting/Self-Monitoring and Reward. Table 5.12 shows the quantitative results (overall mean rating and ranking scores) from S2a and the qualitative results (overall percentage of favorable comments) from S2b with regard to both personal features.

Table 5.12: Triangulating qualitative with quantitative findings on users' receptiveness to Goal-Setting/Self-Monitoring and Reward. Mean Rating = 4, Mean Ranking = 3.5.

	GOAL/SMT		**REWD**	
	COL	**IND**	**COL**	**IND**
Average Rating (1-7 scale)	5.44	4.66	5.07	4.11
Average Ranking (1-6 scale)	4.32	4.85	3.46	4.12
Overall % of favorable comments	24%	39%	29%	0%

Overall, based on the ranking and qualitative measures, the individualist participants are more disposed towards the Goal-Setting/Self-Monitoring feature than the collectivist participants. This is based on the assumption that the individualist participants (4.66/7) might have rated Goal-Setting/Self-Monitoring significantly lower than the collectivist participants (5.44/7) due to their higher level of criticality of the user-interface design of the storyboards. For example, P108 (an individualist participant) remarked on the Goal-Setting/Self-Monitoring storyboard, "*I rated it low because of the spelling mistakes in the storyboard. If the people that worked on the app pay as little attention to coding as they do to the proper use of apostrophes, the app will be a disaster.*" That said, based on the ranking measure, the individualist participants (4.85/6) ranked Goal-Setting/Self-Monitoring higher than the collectivist participants (4.32/6), although the numerical difference is not significant ($p = 0.085$). Moreover, based on the qualitative measure, the individualist participants (39%) have a higher overall percentage of favorable comments than the collectivist participants (24%). Hence, in sum, based on the ranking and qualitative measures, in a personal setting, the individualist group is more likely to be motivated by Goal-Setting/Self-Monitoring than the collectivist group.

Secondly, based on the rating and qualitative measures, the collectivist participants are more disposed towards the Reward feature than the individualist participants. This is based on the assumption that the individualist participants (4.12/6) might have ranked Reward significantly higher than the collectivist participants (3.46/6) because they are less receptive to social strategies such as Cooperation and Social Learning.

That said, based on the rating measure, the collectivist participants (5.07/7) rated Reward significantly higher ($p < 0.01$) than the individualist participants (4.11/7). Moreover, based on the qualitative measure, the collectivist participants (29%) have a higher overall percentage of favorable comments than the individualist participants (0%). Hence, putting it all together, based on the rating and quantitative measures, I conclude that, in a personal setting, Reward is more likely to be effective in the collectivist culture than in the individualist culture. One plausible reason why the individualist participants are less likely to be motivated by the Reward feature, compared with the collectivist culture, is that the reward system depicted on the storyboard is virtual and not tangible. For example, 15% of the individualist participants compared with 9% of the collectivist participants wished the virtual rewards were tangible and convertible to real-life things of value (e.g., money). Another plausible reason is that the physical activity of the individualist group is more likely to be self-driven than by external factors. For example, in S1a, I showed that the physical activity of the individualist group is driven by personal factors such as Self-Efficacy and Self-Regulation, while that of the collectivist group by social factors such as Social Support. This is supported by the finding in S1b: the individualist group (56.5%) reported a higher level of Self-Efficacy than the collectivist group (43.6%).

However, more work needs to be done, especially in real-life application setting, to confirm the above conclusions regarding the culture in which Goal-Setting/Self-Monitoring and Reward will be more effective in personal setting.

5.9 S2c: Investigation of the Drivers of the Receptiveness of the Target Audience to Social Persuasive Features and the Moderating Effect of Culture: A Qualitative Approach

In this section and investigation (S2c), I present the qualitative data analysis, results and discussion with regard to the following subquestion:

> RQ2b. How do the two types of culture differ in their receptiveness to commonly employed social persuasive strategies (features) in the application domain?

Answering this subquestion using a qualitative approach will help confirm the quantitative results in S2a as well as the culture-specific social-cognitive determinants of physical activity in the theory domain.

5.9.1 Data Analysis

The data analysis is based on this particular open question in S2, "*Provide comments about this application feature [persuasive strategy illustrated on the storyboard] to justify your rating here [textbox].*" A thematic analysis was carried out on the comments provided by the study participants on the Cooperation, Social Learning, Social Comparison and Competition storyboards.

5.9.2 Results

The results of the thematic analysis are organized into two major categories:

1. Reasons why users from collectivist and individualist cultures are *likely* to be receptive to social persuasive features; and

2. Reasons why users from collectivist and individualist cultures are *unlikely* to be receptive to social persuasive features.

Reasons Why Users are Likely to be Receptive to Social Features

Table 5.13 shows the reasons behind the study participants' receptiveness to the four social features of a PHA and the overall percentage of participants in each culture that gave favorable comments regarding each reason and feature. I regard the eight reasons as the drivers of the use of a PHA equipped with social features by users in collectivist and individualist cultures. Furthermore, these drivers can be regarded as the strengths of the social features of a PHA [212]. In total, over 20% of participants in each culture (collectivist – 22.6% and individualist – 24.0%) provided favorable comments about the four social features and the eight drivers.

Table 5.13: Reasons why collectivist and individualist users are likely to be receptive to the four social features and the overall percentage of participants' comments. C = Collectivist culture (n = 67), I = Individualist culture (n = 189). Each cell represents the percentage of participants' comments in each culture that is applicable to the driver. The percentages of participants' comments for the eight drivers in each column are not mutually exclusive. The culture-specific percentages in the eleventh and twelfth columns are calculated by averaging across the four social features.

		COOP		**SLEARN**		**SCOMP**		**CMPT**		**All Social Features**	
		C	**I**	**C**	**I**	**C**	**I**	**C**	**I**	**C**	**I**
	Driver / # of Comments	**67**	**189**	**67**	**189**	**67**	**189**	**67**	**189**	**268**	**756**
1	Social feature encourage, challenge and motivate people to exercise	16	10	21	14	13	9	13	15	15.8	12.0
2	Users like/enjoy comparison/competition with others	0	0	0	1	2	3	7	9	2.3	3.3
3	Users' competitive nature makes them want to engage with others	2	0	2	4	0	2	0	7	1.0	3.3
4	Cooperating or competing with others is great, fun and interesting	2	2	0	1	0	4	0	2	0.5	2.3
5	Users do not want to be the reason for the failure of their group	6	4	0	0	0	0	0	0	1.5	1.0
6	Social features engender social pressure that challenges people to act	0	1	0	3	0	0	0	0	0.0	1.0
7	Social features foster accountability among collaborative partners	0	3	0	0	0	0	0	0	0.0	0.8
8	Users like and enjoy team work	6	0	0	1	0	0	0	0	1.5	0.3
	Total % of comments	32	20	23	24	15	18	20	33	22.6	24.0

SS1. Social features encourage, challenge and/or motivate people to engage in exercise behavior. Overall, 15.8% of the tota collectivist participants' comments and 12.0% of the total individualist participants' comments indicate that the four social features challenge and/or motivate users to engage in exercise behavior. Table 5.14 shows most of the participants' comments supporting this theme, which I term the first and foremost reason why collectivist and individualist users are receptive to the social features of a PHA. About 10% (or above) of the comments by each cultural group on each of the four social features relate to this theme. For example, 16% and 21% of the collectivist participants' comments on Cooperation and Social Learning, respectively, relate to the theme in question. Moreover, 15% and 14% of the individualist participants' comments on Competition and Social Learning, respectively, relate to the theme as well.

SS2. Users like and/or enjoy comparison/competition. The second reason why users may be receptive to the social features of a PHA is that they like and/or enjoy comparing themselves and/or competing with others to motivate their engagement in the target behavior. Table 5.15 shows the comments of participants regarding this theme, which is mostly applicable to the Competition and Social Comparison features as expected. Regarding Competition, 7% of the collectivist participants' comments and 9% of the individualist participants' comments relate to this theme. Moreover, regarding Social Comparison, 2% of the collectivist participants' comments and 3% of the individualist participants' comments relate to this theme as well.

SS3. Users' competitive nature makes them want to engage with others. Table 5.16 shows the third reason why users are likely to be receptive to the social features of a PHA: they are (naturally) competitive. This theme is mostly applicable to Competition and Social Learning. Specifically, it is more evident in the individualist participants' comments on both features (7% and 4%, respectively) than in the collectivist participants' comments (0% and 2%, respectively).

SS4. Cooperating or competing with others is great, fun and interesting. Table 5.17 shows the fourth reason why participants are likely to be receptive to the social features of a PHA: collaborating and/or competing with others is great, nice, fun and interesting. This theme is mostly evident in the individualist and collectivist participants' comments on Cooperation (2% and 2%, respectively) and Social Comparison (4% and 0%, respectively).

SS5. Users do not want to be responsible for the failure of their group. Table 5.18 shows the fifth reason why users are likely to be receptive to the social features of a PHA: they do not want to be the cause of the failure of their group when in a social setting. This theme/concern is only applicable to the Cooperation feature, with 6% of the collectivist participants and 4% of the individualist participants expressing it.

SS6. Social features engender social pressures that challenges people to act. Table 5.19 shows the sixth reason why users are likely to be receptive to the social features of a PHA: social features engender social pressure that challenges people to act. This theme is only expressed by 1% and 3% of the individualist participants regarding Cooperation and Social Learning, respectively.

Table 5.14: First reason why collectivist and individualist users are likely to be receptive to social features

COOP		SLEARN		SCOMP		CMPT	
COL	IND	COL	IND	COL	IND	COL	IND
16%	10%	21%	14%	13%	9%	13%	15%

SS1. Social features encourage, challenge and/or motivate people to engage in exercise behavior

- "*Team work helps achieve results faster... **Collaboration will encourage me to do more***" [P197, COL] – COOP.
- "*Cooperating with others **will help me improve***" [P198, COL] – COOP.
- "*The party I'm cooperating with **will go a long way influencing me***" [P205, COL] – COOP.
- "*If i'm into it with someone I respect, **it will definitely influence me***" [P207, COL] – COOP.
- "*working side by side someone makes it fun and **would be encouraged by each other***" [P222, COL] – COOP.
- "*Making exercise a social activity and team effort **would motivate me to exercise more***" [P21, IND] – COOP.
- "*seeing other peoples progress **would heavily influence me to do better** to beat them*" [P27, IND] – COOP.
- "*setting a social goal will **help me work harder***" [P28, IND] – COOP.
- "*This would **help both my friend and I stay motivated to exercise***" [P65, IND] – COOP.
- "*Others achieved goals **will motivate me to achieve ny own goals***" [P193, COL] – SLEARN.
- "*I think **seeing others exercise will go a long to help me***" [P199, COL] – SLEARN.
- "***seen the achievement of others will help me improve my physical activity***" [P213, COL] – SLEARN.
- "*It **would give me motivation to see how my friends are doing***" [P9, IND] – SLEARN.
- "*Seeing my friends progress **could push me to work harder** as I am a competitive person*" [P22, IND] – SLEARN.
- "*If friends and family are working hard it **will make me want to as well***" [P34, IND] – SLEARN.
- "*Being able to see others progress **would push me forward in mine***" [P39, IND] – SLEARN.
- "*Because my friend burn more calories than expected, I **will have to buckle up***" [P217, COL] – SCOMP.
- "*Being able to compare with **others make me want to thrive for excellence***" [P222, COL] – SCOMP.
- "*Comparison **will help you put more effort in burning calories***" [P224, COL] – SCOMP.
- "*It **helps me stay stay on track by trying to meet up with my friends***" [P203, COL] – SCOMP.
- "*Seeing other people close to you succeed could **push you to be included***" [P22, IND] – SCOMP.
- "*Comparing yourself to others **encourages you to do better***" [P28, IND] – SCOMP.
- "*it's good to see how others are doing and **try to match that if i am not keeping up***" [P69, IND] – SCOMP.
- "*comparing with others **motivate to do more***" [P91, IND] – SCOMP.
- "*It **will influence me to do better and be more competitive***" [P179, IND] – SCOMP.
- "*Competing with serious fellow **will change me***" [P199, COL] – CMPT.
- "*Competition like this **steers up more dedication for me***" [P203, COL] – CMPT.
- "*This feature **will motivate me to engage more in physical activity***" [P208, COL] – CMPT.
- "*Competing with others **will motivate me the more to exercise***" [P234, COL] – CMPT.
- "*Competition is healthy .. **keeps one motivated***" [P256, COL] – CMPT.
- "*I am very competitive so going against others **would motivate me for sure***" [P8, IND] – CMPT.
- "*It **would help me achieve more** if I were competing with others*" [P9, IND] – CMPT.
- "*i think this promotes a person to **push themselves harder** and i like that*" [P11, IND] – CMPT.
- "*Competition **would spur me on too to do better!***" [P53, IND] – CMPT.

Table 5.15: Second reason why collectivist and individualist users are likely to be receptive to social features

COOP		SLEARN		SCOMP		CMPT	
COL	IND	COL	IND	COL	IND	COL	IND
0%	0%	0%	1%	2%	3%	7%	9%

SS2. Like and/or enjoy comparison/competition.

- "*I love trying to help people and urge them on.* ***I love the competition*** *or social aspect of this*" [P23, IND] – SLEARN.
- "***Everyone likes to perform better than everyone else***" [P211, COL] – SCOMP.
- "***Like the comparing aspect***" [P172, IND] – SCOMP.
- "***I would want to compete with others*** *" [P18, IND] – SCOMP.*
- "***I really like to compare to my friends*** *so this would be helpful*" [P54, IND] – SCOMP.
- "*I think* ***I like to compete***" [P204, COL] – CMPT.
- "***I like to compete***" [P205, COL] – CMPT.
- "***I love competition and also being on top***" [P211, COL] – CMPT.
- "***I like competition***" [P223, COL] – CMPT.
- "***I enjoy a good competition***" [P16, IND] – CMPT.
- "***I like to compete and compare progress*** *with others*" [P33, IND] – CMPT.
- "***I like competition***" [P41, IND] – CMPT.
- "***I love to compete***" [P87, IND] – CMPT.
- "***I like competition***" [P108, IND] – CMPT.
- "***I like competition*** *so this would likely motivate me*" [P111, IND] – CMPT.
- "***I do enjoy a bit of competition*** *this would potentially motivate me further*" [P126, IND] – CMPT.
- "***I like the idea of being compared to people around me,*** *like city-wide or something*" [P139, IND] – CMPT.
- "***I like to complete.*** *It is a good motivation tool, for myself and to be the best amongst others*" [P179, IND] – CMPT.
- "***I really like to compare to my friends*** *so this would be helpful*" [P54, IND] – SCOMP.

SS7. Social engagement fosters accountability among collaborative partners. Table 5.20 shows the seventh reason why users are likely to be receptive to the social features of a PHA: social features foster accountability among collaborative partners, especially those whose goals and rewards may be tied together. Particularly, this theme of accountability to one's partner is only expressed by 3% of the individualist participants with regard to the Cooperation feature.

SS8. Users like and/or enjoy team work. Table 5.21 shows the eighth reason why users are likely to be receptive to the social features of a PHA: they like and/or enjoy working in a team. This theme is expressed by both collectivist and individualist participants, specifically with regard to the Cooperation and Social Learning features, respectively. However, as shown in Table 5.21, the percentage of collectivist participants (6%) who liked or enjoyed working in a team by way of Cooperation is higher than the percentage of individualist participants (1%) by way of Social Learning.

Table 5.16: Third reason why collectivist and individualist users are likely to be receptive to social features

COOP		SLEARN		SCOMP		CMPT	
COL	IND	COL	IND	COL	IND	COL	IND
2%	0%	2%	4%	0%	2%	0%	7%

SS3. Users' competitive nature makes them want to engage with others.

- "***I will be challenging and competitive***" [P215, COL] – SLEARN.
- "***I am very competitive*** *so I think this would help me a lot*" [P35, IND] – SLEARN.
- "***again i'm a competitive person*** *so any competition would heavily influence me*" [P27, IND] – SCOMP.
- "*This would motivate me more because* ***I am competitive***" [P62, IND] – SCOMP.
- "*It will influence me to do better and* ***be more competitive***" [P179, IND] – SCOMP.
- "***I am very competitive*** *so going against others would motivate me for sure*" [P8, IND] – CMPT.
- "***I'm competitive*** *so I like this*" [P12, IND] – CMPT.
- "***I am really competitive*** *and this would be a huge push for me*" [P35, IND] – CMPT.
- "***im very cometetive*** *and would always want to win*" [P45, IND] – CMPT.
- "*I would find this idea interesting because* ***i am a competitive person***" [P54, IND] – CMPT.
- "***I am competitive****, so this feature would be great for me*" [P157, IND] – CMPT.

Table 5.17: Fourth reason why collectivist and individualist users are likely to be receptive to social features

COOP		SLEARN		SCOMP		CMPT	
COL	IND	COL	IND	COL	IND	COL	IND
2%	2%	0%	1%	0%	4%	0%	2%

SS4. Cooperating or competing with others is great, fun and interesting.

- "***This would be nice to work with someone so we could help each other***" [P15, IND] – COOP.
- "***It would be great to cooperate with friends for rewards points*** *and get healthy too!*" [P53, IND] – COOP.
- "***The cooperation aspects of the app is interesting***" [P59, IND] – COOP.
- "***It could be fun to know if you are doing as well as your friends and family***" [P139, IND] – SLEARN.
- "***It would be nice to see how my peers stack up compared to me in my goals***" [P51, IND] – SCOMP.
- "***it's good to see how others are doing and try to match that*** *if i am not keeping up*" [P69, IND] – SCOMP.
- "***Great feature to know how I achieved and compare my results with others***" [P132, IND] – SCOMP.
- "***social comparison and learning is great***" [P189, IND] – SCOMP.
- "***A little challenge is fun***" [P13, IND] – CMPT.
- "***I would find this idea interesting*** *because* ***i am a competitive person***" [P54, IND] – CMPT.
- "***you're competing with others which is fun***" [P55, IND] – CMPT.

Table 5.18: Fifth reason why collectivist and individualist users are likely to be receptive to social features

COOP		SLEARN		SCOMP		CMPT	
COL	IND	COL	IND	COL	IND	COL	IND
6%	4%	0%	0%	0%	0%	0%	0%

SS5. Users do not want to be responsible for the failure of their group.

- "*Working as team, **I will feel I let someone down if i don't keep my own side of the bargain.***" [P194, COL] – COOP.
- "***I always try to keep my end of the bargain**, so cooperating with a close partner will be interesting*" [P209, COL] – COOP.
- "***I don't want to be the reason for others failure** and I get motivated by team work*" [P210, COL] – COOP.
- "***I would not want to be the reason why a team of two would not have a reward** and I will also motivate my team mate so we can get a reward*" [P211, COL] – COOP.

- "*Helps because you **don't want to let down a friend***" [P3, IND] – COOP.
- "*this might influence since **it makes me feel responsible to someone else and I would be sorry to disappoint***" [P18, IND] – COOP.
- "*It might work because **I would be scared to let others down***" [P31, IND] – COOP.
- "*This would influence me to do better **so my partner won't fail***" [P34, IND] – COOP.
- "*I would probably be less inclined to be in a group **because I wouldn't want to disappoint them if I couldnt make a target***" [P111, IND] – COOP.
- "*If my team member valued the points, **I would feel bad about causing us not to meet targets and earn points***" [P147, IND] – COOP.

Table 5.19: Sixth reason why collectivist and individualist users are likely to be receptive to social features

COOP		SLEARN		SCOMP		CMPT	
COL	IND	COL	IND	COL	IND	COL	IND
0%	1%	0%	3%	0%	0%	0%	0%

SS6. Social features engender social pressure that challenges people to act.

- "***I feel this would be too much pressure to perform***" [P120, IND] – COOP.
- "***Social pressure is an effective motivator**, and can help goals feel like a shared effort*" [P24, IND] – SLEARN.
- "***Social pressure helps one to work out***" [P28, IND] – SLEARN.
- "***Peer pressure is a powerful motivator***" [P62, IND] – SLEARN.
- "*This feature wouldn't be useful to me, but I'm a little different when it comes to social stuff. I feel that such a feature would be incredibly useful for most people, though. I don't engage in social media or talk with people very often; I live a very isolated lifestyle away from others. Anyway, I feel that this feature would be useful to most people since people are able to push harder when they compete with their friends. **It gives an individual more pressure to meet their goals and to avoid failure***" [P25, IND] – SLEARN.
- "*I like how this introduces an element of social competition as a means of motivation to continue and follow through with a workout plan as **I am a competitive person this would work to motivate and influence me to not slack off or take unnecessary time away from physical activity***" [P164, IND] – SLEARN.

Table 5.20: Seventh reason why collectivist and individualist users are likely to be receptive to social features

COOP		SLEARN		SCOMP		CMPT	
COL	IND	COL	IND	COL	IND	COL	IND
0%	3%	0%	0%	0%	0%	0%	0%

SS7. Social features foster accountability among collaborative partners.

- "*It would help motivate and* ***we could keep each other accountable***" [P7, IND] – COOP.
- "***This feature enables my friends and I to hold each other accountable*** *and support each other and push each other to accomplish personal and shared goals which would most likely lead to more success than if we were doing it on our own*" [P42, IND] – COOP.
- "***Having someone to help keep you accountable is always a good motivator***" [P67, IND] – COOP.
- "***Having another person to be accountable*** *to and to encourage* ***makes working out much easier***" [P145, IND] – COOP.
- "*Again,* ***I like this feature as a means of accountability as it may influence myself and the other party to push one another*** *to continue with our given plans and goals*" [P164, IND] – COOP.

Table 5.21: Eighth reason why collectivist and individualist users are likely to be receptive to social features

COOP		SLEARN		SCOMP		CMPT	
COL	IND	COL	IND	COL	IND	COL	IND
6%	0%	0%	1%	0%	0%	0%	0%

SS8. Users like and enjoy team work.

- "***I like to work in team***" [P193, COL] – COOP.
- "***I enjoy team work***" [P215, COL] – COOP.
- "***I like teamwork***" [P245, COL] – COOP.
- "***I love this***" [P218, COL] – COOP.
- "***I love trying to help people and urge them on.*** *I love the competition or social aspect of this*" [P23, IND] – SLEARN.

Reasons Why Users are Unlikely to be Receptive to Social Features

Table 5.22 shows the reasons behind the study participants' non-receptiveness to the four social features and the overall percentage of participants in each culture that gave unfavorable comments regarding each feature. I regard the thirteen reasons as the barriers against the use of a PHA equipped with social features by users. These barriers can be regarded as the weaknesses of the social features of a PHA [212] or the drivers of users' non-receptiveness to the social features of a PHA. They are more evident in the individualist group's comments on all four social features. In total, 37.3% of all of the individualist participants' comments on the four social features, compared with 8.5% of all of the collectivist participants' comments, are related to the thirteen themes.

Table 5.22: Reasons why collectivist and individualist users are unlikely to be receptive to the four social features and the overall percentage of participants' comments. C = Collectivist culture (n = 67), I = Individualist culture (n = 189). Each cell represents the percentage of participants' comments in each culture that is applicable to the driver. The percentages of participants' comments for the eight drivers in each column are not mutually exclusive. The culture-specific percentages in the eleventh and twelfth columns are calculated by averaging across the four social features.

		COOP		**SLEARN**		**SCOMP**		**CMPT**		**All Social Features**	
		C	**I**	**C**	**I**	**C**	**I**	**C**	**I**	**C**	**I**
	Barrier / # of Comments	**67**	**189**	**67**	**189**	**67**	**189**	**67**	**189**	**268**	**756**
1	Users do not like comparison and/or competition with others	0	3	2	8	3	18	7	13	3.0	10.5
2	Users are indifferent to others' exercise, goals and achievements	0	2	3	11	2	6	0	1	1.3	5.0
3	Users do not like working with others in a group setting	2	14	0	3	0	0	0	0	0.5	4.3
4	Comparison/competition could be demotivating and harmful	0	0	0	3	3	6	0	2	0.8	2.8
5	Users' non-competitive nature makes them want to engage with others	0	0	0	1	0	1	2	7	0.5	2.3
6	Users do not want to rely on others for achievement of goals/rewards	2	9	0	0	0	0	0	0	0.5	2.3
7	Users are concerned about privacy and confidentiality	0	2	0	1	0	4	0	2	0.0	2.3
8	Users lack social circles and support from friends and family	0	3	0	2	0	2	0	1	0.0	2.0
9	Users have different levels of motivation, goals and abilities	0	0	2	1	2	4	2	1	1.5	1.5
10	Users do not want to be socially pressured as it causes stress	0	3	2	1	0	1	0	0	0.5	1.3
11	Users do not like sharing goals and progress with others	0	1	0	4	0	1	0	0	0.0	1.5
12	Comparison/competition should be with self and not others	0	0	0	0	0	1	0	3	0.0	1.0
13	No measuring up to others may cause a feeling of failure, guilt or shame	0	1	0	2	0	0	0	0.0	0.0	0.8
	Total % of comments	4	38	9	37	10	44	11	30	8.5	37.3

SW1. Users do not like comparing/competing with others. The first reason why users may not be receptive to social features is that they do not like comparing themselves and/or competing with others as a way of motivating their performance of the target behavior. Table 5.23 shows a cross-section of participants' comments regarding this theme, which is more evident in the individualist group's comments on Social Comparison (18%, compared with 3% for the collectivist group), Competition (13%, compared with 7% for the collectivist group), and Social Leaning (8%, compared with 2% for the collectivist group).

Table 5.23: First reason why collectivist and individualist users are unlikely to be receptive to social features

COOP		SLEARN		SCOMP		CMPT	
COL	IND	COL	IND	COL	IND	COL	IND
0%	3%	2%	8%	3%	18%	7%	13%

SW1. Users do not like comparing/competing with others, just like focusing on self.

"***I would not wish to compare myself*** *to others*" [P133, IND] – COOP.

"***Don't want to compare myself*** *and would not want to rely on someone else*" [P135, IND] – COOP.

"***I would not want to compare goals***" [P87, IND] – COOP.

"***I don't like comparing myself to others*** *when it comes to health and fitness*" [P31, IND] – SLEARN.

"***I don't like to compare myself to others****, as it sets you up for unrealistic goals*" [P36, IND] – SLEARN.

"***I don't like to compare myself to other*** *therefore this feature would be irrelevant*" [P126, IND] – SLEARN.

"***I don't feel like comparing myself with others***" [P133, IND] – SLEARN.

"***I dont want to try to compete, or compare myself***" [P137, IND] – SLEARN.

"***I hate comparison with other people****. It's a silly*" [P140, IND] – SLEARN.

"*I'm not particularly competitive by nature and* ***don't like comparisons***" [P155, IND] – SLEARN.

"***I don't prefer comparing myself with others***" [P205, COL] – SCOMP.

"***I hate comparison***" [P218, COL] – SCOMP.

"***I don't need to compare my exercise goals to that of another***" [242, COL] – SCOMP.

"***I don't compare my performance with others***" [P245, COL] – SCOMP.

"***I don't want to compare myself to other***" [P41, IND] – SCOMP.

"***Not open to comparison****. I workout for me*" [P121, IND] – SCOMP.

"*Once again* ***I don't find myself comparing to others*** *and* ***I don't enjoy it*** *so it wouldn't be relevant to me*" [P126, IND] – SCOMP.

"***I don't feel like comparing myself to others***" [P133, IND] – SCOMP.

"***I don't like competitions***" [P207, COL] – CMPT.

"***I don't like to compete***" [P209, COL] – CMPT.

"***rigorous competition steers me away***" [P215, COL] – CMPT.

"***I dont like compettion***" [P218, COL] – CMPT.

"***i hate competing***" [P114, IND] – CMPT.

"***I don't really care about competing with others***" [P116, IND] – CMPT.

"***Not interest in competing with others***" [P119, IND] – CMPT.

"***I work out for myself not to compare myself against someone.*** *Little motivation here*" [P121, IND] – CMPT.

"***I don't wish to compare myself to others***" [P133, IND] – CMPT.

"***I don't want to compete with others****, I could go over my limits and have an injury*" [P137, IND] – CMPT.

"***I personally don't like competing*** *and don't think it's fun*" [P138, IND] – CMPT.

"***I don't like competition/comparison***" [P140, IND] – CMPT.

"***I do not like to compete***" [P182, IND] – CMPT.

"***I hate competition*** *and it would not influence me*" [P173, IND] – CMPT.

"***I do not like to compete***" [P182, IND] – CMPT.

Table 5.24: Second reason why collectivist and individualist users are unlikely to be receptive to social features

COOP		SLEARN		SCOMP		CMPT	
COL	IND	COL	IND	COL	IND	COL	IND
0%	2%	3%	11%	2%	6%	0%	1%

SW2. Users are indifferent to others' exercise, goals and achievements.

- "***I don't care how others do***" [P147, IND] – COOP.
- "***I wouldn't really care about other people***" [P153, IND] – COOP.
- "*I control my diet and exercise and* ***have no interest in what someone else is doing*** *for theirs.*" [P165, IND] – COOP.
- "***I don't exercise with friend or keep track of my friends exercising*** *therefore this feature isn't important to me*" [P163, IND] – COOP.
- "***I am not always interested in the next persons routine***" [P194, COL] – SLEARN.
- "***I don't like to observe the behaviours to determine my actions***" [P209, COL] – SLEARN.
- "***I don't care how people I know are exercising***" [P29, IND] – SLEARN.
- "***I'm not a fan of seeing what others do.*** *I need to focus on my own achievements*" [P32, IND] – SLEARN.
- "***I don't care if other people meet their goals***" [P38, IND] – SLEARN.
- "***I don't care about other's workouts,*** *they don't interest me. To each his/her own.*" [P43, IND] – SLEARN.
- "***i wouldnt really care about anyone else's goals***" [P45, IND] – SLEARN.
- "***I don't care much about what others are doing.*** *I'm only focused on myself*" [P48, IND] – SLEARN.
- "***I wouldn't*** *share my data or* ***want to know how well or bad someone else is doing***" [P165, IND] – SLEARN.
- "***It doesnt matter to me that others have met their goals***" [P115, IND] – SLEARN.
- "***I don't care all that much about how I stack up next to others***" [P116, IND] – SLEARN.
- "***Dont really care about friends progress to be honest***" [P174, IND] – SLEARN.
- "***I do not really care that much about the progress of other people*** *because I work at my own pace*" [P179, IND] – SLEARN.
- "***I don't really care for other individuals goals***" [P38, IND] – SLEARN.
- "***I'm not a fan of seeing what others do.*** *I need to focus on my own achievements*" [P32, IND] – SLEARN.
- "***I don't like the idea of competing with others,*** *you should only set goals for yourself*" [P186, IND] – SLEARN.
- "***I don't think what others do regarding their body matters to me that much***" [254, COL] – SCOMP.
- "***i dont care what other people are doing***" [P40, IND] – SCOMP.
- "*I only worry about myself when it comes to exercising so* ***comparing to others isn't beneficial for me***" [P48, IND] – SCOMP.
- "***Not too concerned with how well others are doing*** *relevant to myself on its own*" [P106, IND] – SCOMP.
- "***I don't care how others do***" [P129, IND] – SCOMP.
- "***I do not care how my friends are doing on their goals***" [P134, IND] – SCOMP.
- "***I wouldn't care to look at my friends' progress***" [P153, IND] – SCOMP.
- "***don't care what others are doing***" [P154, IND] – SCOMP.
- "***Not interested to see what others are doing with their exercises***" [P157, IND] – SCOMP.
- "***i dont care about others.*** *this is about me*" [P158, IND] – SCOMP.
- "***I don't really care about competing with others***" [P116, IND] – CMPT.
- "***I'm only focused on what I'm achieving; Not others***" [P48, IND] – CMPT.

Table 5.25: Third reason why collectivist and individualist users are unlikely to be receptive to social features

COOP		SLEARN		SCOMP		CMPT	
COL	IND	COL	IND	COL	IND	COL	IND
2%	14%	0%	3%	0%	0%	0%	0%

SW3. Users do not like working with others in a group setting.

- "***I don't really like the idea of tying me to others in a forced relationship***" [P254, COL] – COOP.
- "*It doesn't seem like something that would really be helpful since exercise to me is* ***more of an independent activity***" [P156, IND] – COOP.
- "***It should be individualized***" [P136, IND] – COOP.
- "***I'm not one to work with others on personal goals*** *so this wouldn't have much influence over me*" [P48, IND] – COOP.
- "***I prefer to work out alone*** *to clear my head*" [P127, IND] – COOP.
- "***I hate working with others***" [P128, IND] – COOP.
- "***I don't like team work***" [P140, IND] – COOP.
- "***working out is personal for me,*** *not social*" [P112, IND] – SLEARN.
- "***I work out for myself not anyone else.*** *Not motivated by others work*" [P121, IND] – SLEARN.
- "***I feel like exercise is something personal for me*** *and I would rather not compare myself nor involve friends or coworkers*" [P146, IND] – SLEARN.
- "***More about the personal gain*** *than competition*" [P180, IND] – SLEARN.
- "***Prefer independence in the gym***" [P181, IND] – SLEARN.

SW2. Users are indifferent to others' exercise, goals and achievements. The second reason why users may not be receptive to social features is that they are indifferent to others' behaviors, goals and achievements. Table 5.24 shows a cross-section of participants' comments regarding this theme, which is more evident in the individualist group's comments on Social Learning (11%, compared with 3% for the collectivist group) and Social Comparison (6%, compared with 2% for the collectivist group).

SW3. Users do not like working with others in a group setting. The third reason why users may not be receptive to social features is that they do not like working with others in a collaborative setting towards realizing their health goals. Table 5.25 shows a cross-section of participants' comments regarding this theme, which is more evident in the individualist group's comments on Cooperation (14%, compared with 2% for the collectivist group) and Social Learning (3%, compared with 0% for the collectivist group).

SW4. Comparison/competition could be demotivating and harmful. The fourth reason why users may not be receptive to social features is that comparison/competition could be demotivating due to poor comparative performance and even harmful due to being over-competitive. Table 5.26 shows a cross-section of participants' comments on this theme, which is more evident in the individualist group's comments on Social Comparison (6%, compared with 3% for the collectivist group), Competition (4%, compared with 0% for the collectivist group) and Social Learning (3%, compared with 0% for the collectivist group).

Table 5.26: Fourth reason why collectivist and individualist users are unlikely to be receptive to social features

COOP		SLEARN		SCOMP		CMPT	
COL	IND	COL	IND	COL	IND	COL	IND
0%	0%	0%	3%	3%	6%	0%	4%

SW4. Comparison/competition could be demotivating and harmful.

- "*I do not enjoy comparing my excercise to others because* ***I only feel worse***" [P134, IND] – SLEARN.
- "***Comparing myself to others would likley de-motivate me,*** *i would start thinking I suck compared to kim..etc*" [P141, IND] – SLEARN.
- "*I think it might be motivational when viewing scores of friends with similar fitness, but* ***could demotivate me if I looked at a very high score of a very high friend that I couldn't possibly reach***" [P142, IND] – SLEARN.
- "*My weight loss is my competition, I don't need to compete against other people. Plus,* ***competing with other individuals could be unhealthy*** *(i.e., you might workout too hard, or not eat a healthy amount of food, just to be better than them)*" [P161, IND] – SLEARN.
- "***This App can discourage me*** *if i see that others are doing better*" [P213, COL] – SCOMP.
- "*Although a bit of healthy competition can be motivational,* ***it can also set you up for disappointment,*** *so I'm a bit on the fence here*" [P36, IND] – SCOMP.
- "*Comparing myself to others* ***can be harmful and demotivating.*** *Someone always loses*" [P107, IND] – SCOMP.
- "*It's nice to see your name high up on a list, but* ***can be demotivating when low on the list.*** *This needs to be balanced by offering help or rewards to those on the bottom of the ladder*" [P162, IND] – CMPT.
- "*This might be useful, but only if a lot of my friends are on the app,* ***also if they're way more fit than me, I'd be embarrassed to have my score show up at the bottom of rankings***" [P142, IND] – CMPT.
- "*competing in caloric output* ***can be dangerous***" [P112, IND] – CMPT.

Table 5.27: Fifth reason why collectivist and individualist users are unlikely to be receptive to social features

COOP		SLEARN		SCOMP		CMPT	
COL	IND	COL	IND	COL	IND	COL	IND
0%	0%	0%	1%	0%	1%	0%	7%

SW5. Users' non-competitive nature discourages them from engaging with others.

- "***I am not all that competitive***" [P59, IND] – SLEARN.
- "***I'm not particularly competitive by nature*** *and don't like comparisons*" [P155, IND] – SLEARN.
- "*Again* ***im not really competitive***" [P7, IND] – SCOMP.
- "***I'm not a competitively natured person,*** *so something like this wouldn't benefit me*" [P17, IND] – CMPT.
- "*Other people's goals and achievements don't really influence me* ***not an overly competitive person***" [P160, IND] – CMPT.
- "***I'm not all that competative about fitness***" [P124, IND] – CMPT.
- "*It is* ***unlikely I would be exercising enough to beat my friends***" [P134, IND] – CMPT.
- "***not a competitive person***" [P167, IND] – CMPT.
- "***I am not big on competing with others***" [P15, IND] – CMPT.

SW5. Users' non-competitive nature discourages them from engaging with others. The fifth reason why users may not be receptive to social features is that they are not (very) competitive. Table 5.27 shows a cross-section of participants' comments regarding this theme, which is more evident in the individualist group's comments on Competition (7%) than the collectivist group's (0%).

SW6. Users do not want to rely on others for the achievement of goals/rewards. The sixth reason why users may not be receptive to social features is that they do not want to rely on others for the achievement of their goals/rewards. Table 5.28 shows a cross-section of participants' comments regarding this theme, which is more evident in the individualist group's comments on Cooperation (9%) than the collectivist group's (2%).

Table 5.28: Sixth reason why collectivist and individualist users are unlikely to be receptive to social features

COOP		SLEARN		SCOMP		CMPT	
COL	IND	COL	IND	COL	IND	COL	IND
2%	9%	0%	0%	0%	0%	0%	0%

SW6. Users do not want to rely on others for the achievement of goals/rewards.

- "***when i meet my goal and the second person did not meet his goal it will affect the reward that will be given***" [P213, COL] – COOP.
- "*It's a cool feature, but* ***I wouldn't want to rely on other***" [P8, IND] – COOP.
- "***i don't want to rely on another person to acheive a gamified goal***" [P11, IND] – COOP.
- "*Good Buddy system that keeps people from getting off track.* ***I still don't like the point association though***" [P23, IND] – COOP.
- "***I do not want my progress or reward to be affected by anothers*** *behavior*" [P38, IND] – COOP.
- "***I dont like that my points depend an another persons activity***" [P52, IND] – COOP.
- "*Great feature but* ***to depend on others to be rewarded will be quite unrewarding***" [P61, IND] – COOP.
- "*i like the idea of competing with others but* ***don't want to have to depend on others to meet goals***" [P69, IND] – COOP.
- "***If I was using an app with an exercise buddy, the last thing I would want is for them to be disappointed in me.*** *If the app let one person compensate for the other person's deficiency, that would be good*" [P108, IND] – COOP.
- "***I don't like relying on others, even for virtual points***" [P116, IND] – COOP.
- "***Dont like relying on others for my personal goals***" [P121, IND] – COOP.
- "*Don't want to compare myself and* ***would not want to rely on someone else***" [P135, IND] – COOP.
- "***I don't want to depend on others****, and I don't want to impose on others to do exercise*" [P137, IND] – COOP.
- "***No way would I want to rely on anyone else to get my points***" [P141, IND] – COOP.

SW7. Users are concerned about privacy and confidentiality. The seventh reason why users may not be receptive to social features is that they are concerned about the privacy and confidentiality of their physical-activity data. As shown in Table 5.29, this theme is only evident in the individualist group's comments on all four social features. Regarding Social Comparison, Competition, Cooperation and Social Learning, the percentages of the individualist participants' comments are 4%, 2%, 2% and 1%, respectively, while that of the collectivist partcipants' comments on each social feature is 0%.

SW8. Users lack social circles and support from friends and family. The eighth reason why users may not be receptive to social features is that they lack social circles and support, especially from active family and friends. As shown in Table 5.30, this theme is only evident in the individualist group's comments on all four social features. Regarding Cooperation, Social Learning, Social Comparison and Competition, the percentages of the individualist participants' comments are 3%, 2%, 2% and 1%, respectively, while that of the collectivist partcipants' comments on each social feature is 0%.

SW9. Users have different levels of motivation, goals and abilities. The ninth reason why users may not be receptive to social features is that they believe that individuals have different levels of motivation, goals, abilities and levels of fitness. For this reason, they consider it unfair for users of different physical abilities and skill sets to compete or compare their performance. Table 5.31 shows a cross-section of participants' comments on this theme, which is evident in at least 1% of each cultural group's comments on each social feature, except Cooperation.

SW10. Users do not want to be socially pressured as it causes stress. The tenth reason why participants may not be receptive to social features is that it engenders social pressure which causes stress. Table 5.32 shows a cross-section of participants' comments on this theme, which is mostly evident in the participants' comments on Cooperation (3% for the individualist group and 0% for the collectivist group) and Social Learning (1% for the individualist group and 2% for the collectivist group).

SW11. Users do not like sharing their goals and progress with others. The eleventh reason why users may not be receptive to social features is that they do not like sharing their goals, performance and progress with others, especially on social media, due to concerns about privacy and the belief that physical activity is a personal and not a social endeavor. Table 5.33 shows a cross-section of participants' comments regarding this theme, which is only evident in the individualist group's comments on Social Learning (4%), Social Comparison (1%) and Cooperation (1%).

SW12. Comparison/competition should be with self and not others. The twelfth reason why users may not be receptive to social features is that they believe that physical-activity comparison and/or competition should be with oneself and not others. Table 5.34 shows most of the participants' comments regarding this theme, which is only evident in the individualist group's comments on Competition (3%) and Social Comparison (1%).

Table 5.29: Seventh reason why collectivist and individualist users are unlikely to be receptive to social features

COOP		SLEARN		SCOMP		CMPT	
COL	IND	COL	IND	COL	IND	COL	IND
0%	2%	0%	1%	0%	4%	0%	2%

SW7. Users are concerned about privacy and confidentiality.

- "***I don't want others gossiping about my activity level!***" [P13, IND] – COOP.
- "*I hate this feature.* ***I dont need people knowing my information***" [P49, IND] – COOP.
- "*I don't really care about what other people do, and* ***I wouldn't want anyone looking at my information***" P153, IND] – SLEARN.
- "***Privacy concerns***" [P137, IND] – SLEARN.
- "***I dont want people knowing my sensitive information***" [P49, IND] – SCOMP.
- "***Do not want people looking at my stat***" [P135, IND] – SCOMP.
- "***I don't like share this kind of information with others***" [P137, IND] – SCOMP.
- "*I would not use this app* ***I would rather my personal statistics not be broadcasted***" [P144, IND] – SCOMP.
- "***little too invasive***" [P125, IND] – SCOMP.
- "*At first at least,* ***I would want to keep this stuff private.*** *Once I got more in shape, maybe I would be more inclined to compare/compete*" [P141, IND] – SCOMP.
- "***I would not want other people seeing how I am doing***" [P30, IND] – CMPT.

Table 5.30: Eighth reason why collectivist and individualist users are unlikely to be receptive to social features

COOP		SLEARN		SCOMP		CMPT	
COL	IND	COL	IND	COL	IND	COL	IND
0%	3%	0%	2%	0%	2%	0%	1%

SW8. Users lack social circles and support from friends and family.

- "***My family and friends are not very active*** *so I probably would not participate with them*" [P150, IND] – COOP.
- "***I don't have a lot of contacts*** *that use apps for health and wel-being, so I would probably never achieve my group goals*" [P139, IND] – COOP.
- "***I don't have any friends or family that I exercise with*** *therefore this feature would be irrelevant to me*" [P163, IND] – SLEARN.
- "***I don't think I could convince my friends/family to use the app*** *to make this relevant*" [P138, IND] – SLEARN.
- "*This seems motivating,* ***but if no one else I know is setting goals on there, it's not all that useful***" [P47, IND] – SLEARN.
- "***None of my friends use apps like this***" [P38, IND] – SCOMP.
- "***I have no one to share the app with***" [P83, IND] – SCOMP.
- "*Like I said,* ***not a lot of friends and family to compare with***" [P139, IND] – SCOMP.
- "***i don't know other people***" [P70, IND] – CMPT.
- "***This might be useful, but only if a lot of my friends are on the app****, also if they're way more fit than me, I'd be embarrassed to have my score show up at the bottom of rankings*" [P142, IND] – CMPT.

Table 5.31: Ninth reason why collectivist and individualist users are unlikely to be receptive to social features

COOP		SLEARN		SCOMP		CMPT	
COL	IND	COL	IND	COL	IND	COL	IND
0%	0%	2%	1%	2%	4%	2%	1%

SW9. Users have different levels of motivation, goals and abilities.

- "***People have different physical builds and strengths***" [P202, COL] – SLEARN.
- "***Some of my friends might not have the same level of motivation*** *therefore I would not like this feature*" [P234, COL] – SCOMP.
- "*I do not really compare myself to others because* ***I am the type who works at my own pace***" [P50, IND] – SCOMP.
- "***People burn different calories based on bw. This is apples and oranges***" [P102, IND] – SCOMP.
- "***This isnt helpful comparing the calorie intake of different body types***" [P113, IND] – SCOMP.
- "*I dont believe in fitness challenges.* ***Much of fitness is genetic and therefore, unfair***" [P52, IND] – SCOMP.
- "*my progress and failure it's a bit personal, won't want to engage in a competition as* ***our strengths, goals and targets are not same***" [P220, COL] – CMPT.
- "***People have different goals. It's hard to compete when we all have different goals***" [P32, IND] – CMPT.
- "*This seems motivating to me, but it might be* ***difficult to win against people who are more fit or who have more time to exercise****, which would have to be controlled for*" [P47, IND] – CMPT.

Table 5.32: Tenth reason why collectivist and individualist users are unlikely to be receptive to social features

COOP		SLEARN		SCOMP		CMPT	
COL	IND	COL	IND	COL	IND	COL	IND
0%	3%	2%	1%	0%	1%	0%	0%

SW10. Users do not want to be socially pressured as it causes stress.

- "***I don't care for this sort of pressure****, but it would probably be effective with certain people*" [P24, IND] – COOP.
- "***I would not like the pressure of affecting someone else's bonus.*** *I wouldn't do this*" [P33, IND] – COOP.
- "*While the group goal setting is unique and interesting, I personally would not use an app with this feature.* ***The social pressure to reach that goal would only increase my stress level***" [P104, IND] – COOP.
- "*I don't like being responsible for other people's success or* ***failure in achieving goals too much pressure***" [P155, IND] – COOP.
- "*for me if the app has this feature i will drop the app, as* ***i dont need pressure from friends and family is achieving my goals***" [P206, COL] – SLEARN.
- "*The social element is more convincing, but also* ***puts an increase on social pressure to complete goals. For this reason I would not use the app***" [P104, IND] – SLEARN.
- "***Social pressure to be 'level' with others would mean I would not use the app***" [P104, IND] – SCOMP.

Table 5.33: Eleventh reason why collectivist and individualist users are unlikely to be receptive to social features

COOP		SLEARN		SCOMP		CMPT	
COL	IND	COL	IND	COL	IND	COL	IND
0%	1%	0%	4%	0%	1%	0%	0%

SW11. Users do not like sharing goals and progress with others.

- "*As stated earlier physical activity is something* ***I would rather not share with others***" [P146, IND] – COOP.
- "*Again,* ***I'm not one to share my goals***" [P10, IND] – SLEARN.
- "***I dont really do social media***" [P16, IND] – SLEARN.
- "*I'm not influenced by others,* ***I think the oversaturation of people sharing their 'achievements' on FB and other social apps have diminished the significance of this***" [P162, IND] – SLEARN.
- "***I'm not interested in social media***" [P166, IND] – SLEARN.
- "***I don't like sharing my progress with others***" [P107, IND] – SLEARN.
- "***I don't think I would want to share my goals with others****. I'm more solitary*" [P10, IND] – SLEARN.
- "***I wouldn't share my data*** *or want to know how well or bad someone else is doing*" [P165, IND] – SLEARN.
- "***I prefer keeping my goals personal***" [P119, IND] – SLEARN.
- "***I don't like share this kind of information with others***" P137, IND] – SCOMP.
- "*I think this would be very convincing, especially if I was compared to my family members, but* ***I would have to be able to add my contacts myself*** *(ie* ***not linked account to social media****), because it wouldn't motivate me if I was given comparisons to some random person I haven't seen in years*" [P142, IND] – SCOMP.

Table 5.34: Twelfth reason why collectivist and individualist users are unlikely to be receptive to social features

COOP		SLEARN		SCOMP		CMPT	
COL	IND	COL	IND	COL	IND	COL	IND
0%	0%	0%	0%	0%	1%	0%	3%

SW12. Comparison/competition should be with self and not others.

- "***I prefer to compare myself only yo my own progress***" [P14, IND] – SCOMP.
- "***I am more self competitive.*** *I dont want to compete with friends over exercising*" [P10, IND] – CMPT.
- "*Competition inspires some people, but* ***I typically only worry about improving relative to myself***" [P24, IND] – CMPT.
- "***I exercise alone and compete with myself***" [P29, IND] – CMPT.
- "***I feel we are better off comparing ourselves to ONLY ourselves*** *- otherwise we might not feel so great being at the bottom of the list*" [P150, IND] – CMPT.

SW13. Not measuring up to others may cause a feeling of failure, guilt or shame. The thirteenth reason why users may not be receptive to social features is that they believe that not measuring up to others may cause a feeling of failure, guilt or shame. As shown in Table 5.35, this theme is more evident in the individualist group's comments on Social Learning (2%, compared with 0% for the collectivist group) and Cooperation (1%, compared with 0% for the collectivist group).

Table 5.35: Thirteenth reason why collectivist and individualist users are unlikely to be receptive to social features

COOP		SLEARN		SCOMP		CMPT	
COL	IND	COL	IND	COL	IND	COL	IND
0%	1%	0%	2%	0%	0%	0%	0%
SW13. Not measuring up to others may cause a feeling of failure, guilt or shame. - "*If my team member valued the points, **I would feel bad about causing us not to meet targets and earn points***" [P147, IND] – COOP. - "*This seems very guilt based, which is an important motivator for some but **I would hate it***" [P159, IND] – COOP. - "*Comparing myself to others would likley de-motivate me, **i would start thinking I suck compared to kim..etc***" [P141, IND] – SLEARN. - "*I don't believe in a comparison to other people because **it seems to men others motivated through guilt***" [171, IND] – SLEAN. - "***Although the guilt would probably be a bit helpful** I don't think that would make that much of a difference to me*" [P156, IND] – SLEARN.							

5.9.3 Discussion

In have presented a thematic analysis of the drivers of users' receptiveness and non-receptiveness to four commonly employed social features of a PHA. In the following discussion, I focus on each of the drivers, supported with examples of participants' comments, the cultural differences and a triangulation of some of the findings (qualitative) with those of S2a (quantitative).

Reasons Why Social Features Motivates Users

In this section, I discuss the main reasons why users in both types of culture are likely to be receptive to social features by drawing on samples of participants' comments to support each reason.

SS1. Social features encourage, challenge and/or motivate people to engage in exercise behavior. The first and foremost reason why collectivist and individualist users are likely to be receptive to the social features of a PHA is that they challenge and/or motivate users to engage in the target behavior. Table 5.14 shows most of the participants' comments supporting this theme. For each culture, about 10% (or above) of the participants' comments on each social feature relate to this theme. Overall, 16% of the 268 collectivist comments and 12% of the 756 individualist comments suggest that the social features of a PHA have the potential to encourage, challenge and/or motivate users to engage in exercise behavior.

Regarding Cooperation, P160 (a collectivist participant) commented that "***[t]eam work helps achieve results faster... Collaboration will encourage me to do more***," and P26 (an individualist participant) commented that "***I would feel motivated to reach my goals knowing someone else is working along side me with those goals.***" Particularly, the thematic analysis shows that the idea of employing Cooperation as a social strategy for motivating behavior change resonates more with the collectivist participants (16%) than the individualist participants (10%).

Secondly, regarding Social Learning, P197 (a collectivist participant) commented that "***[s]eeing your friends can achieve their set goal, it would encourage me to do same.. More like 'if they can do it, I can too'.***" Similarly, P22 (an individualist participant) commented that "***[s]eeing my friends progress could push me to work harder as I am a competitive person.***" Both comments indicate the potential of employing Social Learning as a social strategy to motivate behavior change in both cultures. However, Social Learning as a social strategy for motivating behavior change resonates more with the collectivist culture (21% of the 67 comments) than with the individualist culture (14% of the 189 comments).

Thirdly, regarding Social Comparison and Competition, the participants' comments show that both cultures are likely to be receptive to both social features. For example, in the collectivist culture, P222 commented that "***[b]eing able to compare with others make me want to thrive for excellence***," and P234 commented that "***[c]ompeting with others will motivate me the more to exercise.***" Similarly, in the individualist culture, P42 commented that Social Comparison "***would motivate me to try harder to accomplish my goals like my friends are***," and P53 commented that "***[c]ompetition would spur me on too to do better!***" As shown in Table 6.13, the idea of employing Social Comparison as a social strategy to motivate exercise behavior resonates more with the collectivist participants (13%) than the individualist participants (9%). This indicates that Social Comparison is more likely to be effective in motivating behavior change in the collectivist culture than in the individualist culture. Moreover, although the idea of employing Competition as a social strategy to motivate exercise behavior resonated more with the individualist participants (15%) than the collectivist participants (13%), the cultural difference is small (2%).

It is worthy of note that the overall finding on the motivational potential of Social Comparison and Competition replicates that of Orji et al. [33] in the eating domain. Specifically, the authors found that both social features challenge and push users towards their goals through commitment and focus on the achievement of the target behavior [33]. The underlying theme of commitment and focus is evident in the current study as well. For example, P203 commented that "***[c]ompetition like this steers up more dedication for me***," and P164 commented that Competition "***would motivate and influence me to push harder every day to achieve the top rank*** *(or attempt to) therefore* ***this level of competition does indeed convince influence motivate me*** *and is directly relevant to myself.*"

SS2. Users like and/or enjoy comparison/competition. The second reason why users are likely to be receptive to social features is that they like and/or enjoy comparing themselves and/or competing with others to motivate their engagement in exercise behavior. Table 5.15 shows the comments of participants regarding this theme which is more evident in the comments on Social Comparison and Competition. Regarding Social Comparison, 2% of the collectivist participants' comments and 3% of the individualist participants' comments relate to the "comparison/competition" theme. For example, in the collectivist culture, P211 commented that, in the process of comparison, "***[e]veryone likes to perform better than everyone***

else. Similarly, in the individualist culture, P54 commented that "***I really like to compare to my friends so this would be helpful.***" Regarding Competition, 7% of the collectivist participants' comments and 9% of the individualist participants' comments relate to the "comparison/competition" theme as well. For example, P211 (a collectivist participant) commented that "***I love competition and also being on top.***" Similarly, P126 (an individualist participant) commented that "***I do enjoy a bit of competition this would potentially motivate me further.***" Overall, regarding all four social features, 2.3% of the total collectivist participants' comments and 3.3% of the total individualist participants' comments relate to this theme. Although the overall percentage of the individualist group's comments on the "***I like/enjoy comparison/competition***" theme is higher than that of the collectivist group's comments, the percentage difference between both cultures is relatively small (1%).

SS3. Users' competitive nature makes them want to engage with others. The third reason why users may be receptive to the social features of a PHA is that they are (naturally) competitive. This theme, as shown in Table 5.16, characterizes more of the individualist participants' comments (3.3% of their total comments), especially on Social Learning, Social Comparison and Competition, than the collectivist participants' comments (1.0% of their total comments). For example, regarding Social Learning, in the collectivist culture, P215 commented that "***I will be challenging and competitive.***" Similarly, in the individualist culture, P56 commented that "***I've always been a competitive person****, and seeing someone else reach their goals will push me even harder to reach my own while also trying to top them.*" Specifically, regarding Competition, only the individualist participants' comments (7%) relate to the theme in question. For example, P35 commented, "***I am really competitive*** *and this would be a huge push for me.*" Moreover, P56 commented, "*As I said before,* ***I'm a competitive person*** *and this feature here is why I would now buy this product. Working to top the leader board would really help me to work hard and lose weight.*"

SS4. Cooperating or competing with others is fun and interesting. The fourth reason why users are likely to be receptive to the social features of a PHA is that collaborating or competing with others is fun and interesting. Table 5.17 shows the comments of participants regarding this theme. Similar to the "being competitive" theme, the "fun and interesting" theme is more applicable to the individualist participants (2.3% of their total comments) than the collectivist participants (0.5% of their total comments). For example, regarding Cooperation, in the collectivist culture, P206 commented, "*As much i don[']t like the fact that i have t[o] see the goals of friend and know if the achieved that goal or not,* ***the cooperative part of it is interesting.***" Similarly, in the individualist culture, P59 commented, "***The cooperation aspects of the app is interesting.***" Moreover, regarding Social Learning, P139 (an individualist participant) commented that "***It could be fun to know if you are doing as well as your friends and family.***" Finally, regarding Social Comparison and Competition, in the individualist culture, P189 commented, "***social comparison and learning is great.***" Similarly, P54 commented, "***I would find this idea [competition] interesting*** *because [I] am a competitive person.*"

It is noteworthy that the current finding (social engagement is fun and interesting) replicates Orji et al.'s

[33] finding in the eating domain. The authors found that Cooperation, Social Comparison and Competition make "*health behaviours fun, exciting, interesting, and appear easier to do than usual*" (p. 1463).

SS5. Users do not want to be responsible for the failure of their group. The fifth reason why users are likely to be receptive to the social features of a PHA is that they do not want to be the cause of the failure of their group when they are cooperating with others in a social setting. Specifically, this theme is only applicable to the Cooperation feature (Table 5.18), with 6% of the collectivist participants and 4% of the individualist participants expressing it. As shown in the storyboard for Cooperation (see Figure 6.4), the reward of the users in the same group (as well as their goal) is tied together. As such, for the group to receive its joint reward, all members of the group must achieve their individual goals (summed up to realize the collectivist goal). Thus, aware of this constraint, the participants, whose comments are presented in Table 5.18, remarked that they would not want to be responsible for the failure of their group. For example, in the collectivist culture, P194 commented that "*[w]orking as team,* ***I will feel I let someone down if i don't keep my own side of the bargain***," and P210 commented that "***I don't want to be the reason for others failure*** *and I get motivated by team work.*" Similarly, in the individualist culture, P31 commented that "*[i]t might work because* ***I would be scared to let others down***," and P34 commented that Cooperation "*would influence me to do better* ***so my partner won't fail.***"

Overall, the current finding (users not wanting to let down their group) is in line with Orji et al.'s [33] finding in the eating domain. The authors found that Cooperation "*raises users' sensitivity to disappointment and makes them work harder to avoid disappointing other people and themselves*" (p. 1465).

SS6. Social features engender social pressure that challenges people to act. The sixth reason why users may be receptive to the social features of a PHA is that they foster social pressures that challenges them to act. As shown in Table 5.19, this theme is expressed only by the individualist participants with regard to Social Learning (3%) and Cooperation (1%). For example, regarding Social Learning, P24 commented, "***Social pressure is an effective motivator****, and can help goals feel like a shared effort.*" Similarly, P25 commented that Social Learning "***gives an individual more pressure to meet their goals*** *and to avoid failure.*" Specifically, P164, who believed he was a competitive person, remarked that Social Learning "***would work to motivate and influence me to not slack off or take unnecessary time away from physical activity.***" Finally, regarding Cooperation, P120 felt that working with others "***would be too much pressure to perform.***"

Orji et al. [33] also found similar results in the eating domain, especially regarding Social Comparison.

SS7. Social engagement fosters accountability among collaborative partners. The seventh reason why users are likely to receptive to the social features of a PHA is that they make people to be accountable to their partners. As shown in Table 5.20, only the individualist participants (3% of them) expressed this theme regarding Cooperation. For example, P42 commented that "***[t]his feature enables my friends and I to hold each other accountable*** *and support each other and push each other to accomplish personal and shared goals.*" Similarly, P145 commented that "***[h]aving another person to be accountable to*** *and* *to encourage* ***makes working out much easier.*** Finally, P164 commented that "***I like this feature as a means of accountability as it may influence myself and the other party to push one another*** *to continue with our given plans and goals.*"

SS8. Users like and/or enjoy team work. The eighth reason why users are likely to be receptive to the social features of a PHA is that they like and/or enjoy working in a team. This theme is mostly evident among the collectivist participants regarding Cooperation. As shown in Table 5.21, 6% of the collectivist participants (compared with 0% of the individual participants) commented categorically that they like and/or enjoy cooperating (collaborating) with others. For example, P193, P215 and 245 (all of whom are collectivist participants) commented that "***I like to work in team***," "***I enjoy team work***," and "***I like teamwork***," respectively. These comments are a confirmation that collectivist users are more likely to be receptive to the Cooperation feature of a PHA than individualist users as the quantitative analysis in Table 5.3 showed. Moreover, only 1% of the individual participants (particularly P23), regarding Social Learning, commented that "***I love trying to help people and urge them on***. *I love the competition or social aspect of this.*" However, for this individualist participant, the love for wanting to help others to achieve their health goal seems to be borne out of the competitive (and not the cooperative) atmosphere Social Learning fosters, as evident in the last part of his comment.

Reasons Why Social Features may not Motivates Users

In this section, I discuss the main reasons why users in both types of culture are unlikely to be receptive to social features by drawing on samples of participants' comments to support each reason.

SW1. Users do not like comparing/competing with others. The first reason why users are unlikely to be receptive to the social features of a PHA is that they do not like comparing themselves and/or competing with others as a way to motivate their exercise behavior. Table 5.23 shows examples of participants' comments regarding this theme, which is more evident in the individualist group's comments on all four social features.

Regarding Social Comparison, for example, 18% of the individualist participants commented that they did not like comparing and/or competing with others compared with 3% of the collectivist participants. The reasons that a higher percentage of individualist participants do not like Social Comparison include lack of enjoyment, not wanting to compete, not wanting to be motivated through guilt, wanting to focus on oneself, wanting to exercise at one's own pace, viewing exercise as a personal act, etc. For example, P126 commented, "*Once again* ***I don't find myself comparing to others and I don't enjoy it so it wouldn't be relevant to me***," and P171 commented, "***I don't believe in a comparison to other people*** *because it seems to me[a]n others motivated through guilt.*" Moreover, P146 commented that "*I feel like exercise is something personal for me and* ***I would rather not compare myself*** *nor involve friends or coworkers*," and P181 commented that "***I prefer the independence of exercise.***" On the other hand, the collectivist participants do not just like comparing or competition. For example, regarding Social Comparison, P218 and P205 commented that "***I hate comparison***" and "***I don't prefer comparing myself with others***," respectively.

Furthermore, regarding Competition, 13% of the individualist participants and 7% of the collectivist participants commented that they did not like comparing and/or competing with others. The reason why participants did not like competing with others include not having interest, going over limits, not being fun, viewing and believing exercise is personal, individuals having different physical abilities and goals, etc. For example, P165 (an individualist participant) commented that "***my success is my own alone...*** *Others have their own idea of success*," and P220 (a collectivist participant) commented that "***my progress and failure it's a bit personal****, won't want to engage in a competition as our strengths, goals and targets are not same.*" Moreover, regarding Competition being unhealthy, P137 (an individualist participant) commented that "***I don't want to compete with others****, I could go over my limits and have an injury*," and P161 (an individualist participant) commented that "***I wouldn't really want to compete with others during weightloss****, i think it could be unhealthy (i.e., trying to lose weight too fast, working out too hard, starving yourself to get in under your calorie goal, etc.).*"

Finally, regarding Cooperation and Social Learning, more individualist participants commented that they did not like comparing themselves with others than collectivist participants. In particular, regarding Cooperation, P122 commented that "***I don[']t need to compare myself or need the help of others to get to my goals.***" Moreover, regarding Social Learning, P155 commented that "*I'm not particularly competitive by nature and* ***don't like comparisons.***" Moreover, P36 does not like Social Learning because ***it sets you up for unrealistic goals***."

SW2. Users are indifferent to others' exercise, goals and achievements. The second reason why users are unlikely to be receptive to the social features of a PHA is that they are indifferent to others' exercise, goals and achievements. Table 5.24 shows examples of participants' comments regarding this theme, which is more evident in the individualist group's comments on Social Learning and Social Comparison.

Regarding Social Learning, 11% of the individualist participants, compared with 3% of the collectivist participants, commented that they were indifferent to other's exercise. For example, among the individualist participants, P165 commented that "*I control my diet and exercise and* ***have no interest in what someone else is doing*** *for theirs*" Specifically, P38 commented that "***I don't care if other people meet their goals,***" and P43 commented that "***I don't care about other's workouts****, they don't interest me. To each his/her own.*" Similarly, among the collectivist participants, P209 commented that "***I don't like to observe the behaviours to determine my actions.***"

Moreover, regarding Social Comparison, 6% of the individualist participants, compared with 2% of the collectivist participants, commented that they were indifferent to other's exercise to the extent that they would not want to compare their performance with others' performance. For example, among the individualist participants, P48 commented that "*I only worry about myself when it comes to exercising so* ***comparing to others isn't beneficial for me***," and P157 commented that he is "***[n]ot interested to see what others***

are doing with their exercises. ” Similarly, among the collectivist participants, P254 commented that “***I don't think what others do regarding their body matters to me that much.***” The finding that a higher percentage of the individualist participants are indifferent to others' exercise and goals than the percentage of the collectivist participants confirms the quantitative results from the between-group analysis presented in Table 5.3. The quantitative results show that individualist users are less likely to be receptive to social features, including Social Comparison, than collectivist users.

SW3. Users do not like working with others in a group setting. The third reason why users may not be receptive to the social features of a PHA is that they do not like working with others in a collaborative setting towards realizing their exercise goals. Table 5.25 shows examples of participants' comments regarding this theme, which is more evident in the individualist group's comments on Cooperation and Social Learning.

Regarding Cooperation, 14% of the individualist participants, compared with 2% of the collectivist participants, commented that they would not like to work with others in a cooperative setting because they consider exercise as a personal activity. For example, among the individualist participants, P48 commented that “***I'm not one to work with others on personal goals*** *so this wouldn't have much influence over me.*” Similarly, P127 commented that “***I prefer to work out alone*** *to clear my head*,” and P128 commented outright that “***I hate working with others.***” Among the collectivist participants, P254 commented that “***I don't really like the idea of tying me to others in a forced relationship.***”

Moreover, regarding Social Learning, 3% of the individualist participants, compared with 0% of the collectivist participants, commented that they did not like working with others because they see exercise as a personal activity. For example, P112 commented that “***working out is personal for me****, not social*,” and P121 commented that “***I work out for myself not anyone else.*** *Not motivated by others work.*”

Overall, this qualitative finding confirms the quantitative results presented in Table 5.3: individualist users are less likely to be receptive to social features, such as Cooperation, than collectivist users.

SW4. Comparison/competition could be demotivating and harmful. The fourth reason why users are unlikely to be receptive to the social features of a PHA is that comparison/competition could be demotivating and even harmful as a result of poor comparative performance and being over-competitive, respectively. Table 5.26 shows examples of participants' comments regarding this theme, which is more evident in the individualist group's comments than in the collectivist group's comments on Social Comparison (6% vs. 3%), Competition (4% vs. 0%) and Social Learning (3% vs. 0%).

Regarding Social Comparison, among the individualist participants, P161 commented that “***competing with other individuals could be unhealthy.***” For this participant, it might make you “***workout too hard, or not eat a healthy amount of food****, just to be better than them*,” which may be harmful to your health. While P161's concern is health-based, P107's is socially based: she is not comfortable with the idea of being a “loser.” This is evident in her comment, “*Comparing myself to others* ***can be harmful and demotivating.*** *Someone always loses.*” Similarly, among the collectivist participants, P213, just like P231, commented that comparing oneself with others will “***discourage me*** *if i see that others are doing better.*”

Regarding Competition, among the individualist participants, P162 commented that he will be "***embarrassed to have my score show up at the bottom of rankings***," especially if he is competing with friends that are "***way more fit than me.***" Similarly, P162 commented that "*[i]t's nice to see your name high up on a list, but* ***can be demotivating when low on the list.*** *This needs to be balanced by offering help or rewards to those on the bottom of the ladder.*" This participant suggested that, to encourage users who are at the bottom of a leaderboard in a competitive setting, they ought to be rewarded with something (e.g., some points) as well as those at the top so that those lagging behind would not be completely discouraged.

Finally, regarding Social Learning, similar "demotivation" concerns are expressed by a number of individualist participants. For example, P141 commented that "***[c]omparing myself to others would lik[el]y de-motivate me****, [I] would start thinking I suck compared to kim..etc.*" P142 also re-echoed the "demotivation" concern with regard to relative poor performance. She commented that though "*I think it might be motivational when viewing scores of friends with similar fitness, but* ***could demotivate me if I looked at a very high score of a very high friend that I couldn't possibly reach.***"

SW5. Users' non-competitive nature discourages them from engaging with others.. The fifth reason why users are unlikely to be receptive to the social features of a PHA is that they are not (very) competitive. This theme resonates more with the individualist participants than the collectivist participants as evident in their comments regarding Competition (Table 5.27). Specifically, 7% of the individualist participants, compared with 0% of the collectivist participants, commented that they were not competitive. For example, P155 commented that "***I'm not particularly competitive by nature***;" therefore, "*[I] don't like comparisons.*" Moreover, P17 commented that "***I'm not a competitively natured person****, so something like this wouldn't benefit me.*"

SW6. Users do not want to rely on others for the achievement of goals/rewards. The sixth reason why users are unlikely to be receptive to the social features of a PHA is that they do not want to rely on others for the achievement of their goals/rewards. Table 5.28 shows examples of participants' comments regarding this theme, which is more evident in the individualist group's comments on Cooperation.

Specifically, 9% of the individualist participants, compared with 2% of the collectivist participants, commented that they would not like rely or depend on others for the achievement of their goals and rewards. For example, P11 categorically commented that "***i don't want to rely on another person to ach[ie]ve a gamified goal.***" Though P23 believed that Cooperation is a "*Good Buddy system that keeps people from getting off track*," he "***still do[es]n't like the point association though.***" Particularly, P108 would prefer a scenario whereby the app can compensate for one partner's poor performance to prevent disappointment when she achieved her goal but was unable to be rewarded for it due to her goals and rewards being tied to her partner's. She commented thus, "***If I was using an app with an exercise buddy, the last thing I would want is for them to be disappointed in me.*** *If the app let one person compensate for the other person's deficiency, that would be good.*" In the collectivist group, only one participant expressed concern about how the other person not meeting his part of the joint goal may affect the joint reward. P213 commented that "***when i meet my goal and the second person did not meet his goal it will affect the reward that will be given.***" However, she did not categorically say she would not want to depend or rely on that person as many of the concerned individualist participants did.

Overall, individualist users are less likely than collectivist users to depend or rely on others for the accomplishment of their goals and achievement of their rewards.

SW7. Users are concerned about privacy and confidentiality. The seventh reason why users are unlikely to be receptive to the social features of a PHA is that they are concerned about privacy and confidentiality with regard to their physical-activity data. This concern resonates only with the individualist participants, who think physical activity is a personal endeavor and thus should be kept from the prying/invasive eyes and wagging tongues of others.

As shown in Table 5.29, 2%, 1%, 4% and 2% of the individualist participants, compared with 0% of the collectivist participants (in all four cases), expressed concern about privacy and confidentiality regarding Cooperation, Social Learning, Social Comparison and Competition, respectively. In particular, P49 viewed physical-activity data as sensitive information, and, as such, would not want to be involved in social comparison. Thus, he commented, "***I don[']t want people knowing my sensitive information.***" Moreover, P13 did not want other people talking about her physical activity. Thus, she commented, "***I don't want others gossiping about my activity level!***" Yet, P144 considered his physical-activity performance as personal, which should not be seen by others by means of social comparison. Thus, he commented, "*I would not use this app* ***I would rather my personal statistics not be broadcasted.***" Moreover, P141 would want to keep his physical activity private until he is fit and comfortable to compare his performance with others. For this reason, he commented, "*At first at least,* ***I would want to keep this stuff private.*** *Once I got more in shape, maybe I would be more inclined to compare/compete.*" However, for P107, if at all others would see his physical-activity data as a result of being in a competition with them, then it would be better that he and they did not know each other. Particularly, he commented regarded Competition thus, "***If I didn't know the people I would love this.*** *If I did know them then I wouldn't use it.*"

Overall, individualist users are more likely than collectivist users to be concern about privacy and confidentiality. As such, individualist users are less likely than collectivist users to use a PHA in a social setting, especially if the app does not protect their identity.

SW8. Users lack social circles and support from friends and family. The eighth reason why users are unlikely to be receptive to the social features of a PHA is that they lack social circles and support from friends and family, especially active people with similar health goals with whom they can work together and/or share their goals and progress. This concern is only evident in the individualist participants' comments as shown in Table 5.30. Specifically, 3%, 2%, 2% and 1% of the individualist participants, compared with 0% of the collectivist participants (in all four cases), expressed concern about limited or lack of social circles and support regarding Cooperation, Social Learning, Social Comparison and Competition, respectively.

For example, P150 said he might not take part in a cooperative physical activity because he lacked active family and friends. Specifically, he commented, "***My family and friends are not very active*** *so I probably would not participate with them.*" P139 and P138 shared the same concern with respect to the Cooperation feature. P139 commented that "***I don't have a lot of contacts*** *that use apps for health and well-being, so I would probably never achieve my group goals*," and P138 commented that "I don't think I could convince anyone to use the app with me." Moreover, a number of individualist participants expressed the same concern regarding Social Learning. For example, P163 commented that "***I don't have any friends or family that I exercise with*** *therefore this feature would be irrelevant to me*," and P47 remarked that "*[t]his seems motivating, but* ***if no one else I know is setting goals on there****, it's not all that useful.*"

Furthermore, the "lack of social circle/support" concern, as prior research [25] shows, is expressed by a number of individualist participants regarding Social Comparison and Competition. For example, P139 commented that he did "***not [have] a lot of friends and family to compare with.***" Although P142 thought the Competitive feature "***might be useful, but only if a lot of my friends are on the app.***"

Overall, individualist users are more likely to not have or get social support for their physical activity than collectivist users. This finding is consistent with the Hofstede's [131] finding that people in individualist cultures tend to work independently to achieve personal goals, while people in collectivist cultures tend to work together to achieve a collective goal.

SW9. Users have different levels of motivation, goals and abilities. The ninth reason why users are unlikely to be receptive to the social features of a PHA is that they believe that individuals have different levels of motivation, goals, abilities, levels of fitness and thus cannot be involved in a comparison/competition-based physical activity. As shown in Table 5.31, this theme is more evident in the participants' comment on Social Comparison, Competition and Social Learning.

Regarding Social Comparison, 4% of the individualist participants' comments and 2% of the collectivist participants' comments are related to the theme. For example, P234 commented that "***Some of my friends might not have the same level of motivation*** *therefore I would not like this feature.*" Similarly, P102 commented that "***[p]eople burn different calories based on bw [bodyweight]. This is apples and oranges.***" For this participant, comparing calories burned by different people with different bodyweights may not be ideal because, perhaps, a person with a higher bodyweight is more likely to burn more calories than a person with a lower bodyweight. For this reason, this participant described comparing these persons to comparing "apples and oranges." Further, P52 viewed physical fitness as genetic. In his words, "***[m]uch of fitness is genetic and therefore, unfair***" thus, "***I don[']t believe in fitness challenges.***" As a result of the different physical abilities possessed by different people, a number of participants from both cultures thought it might be unfair for people with different abilities and goals to be involved in competition. For example, regarding Competition, P47 commented that "*[t]his seems motivating to me, but it might be* ***difficult to win against people who are more fit or who have more time to exercise****, which would have to be controlled for.*" Similarly, P220 commented that "*my progress and failure it's a bit personal, won't want to engage in a competition* ***as our strengths, goals and targets are not same.***"

SW10. Users do not want to be socially pressured as it causes stress. The tenth reason why users are unlikely to be receptive to the social features of a PHA is that they engender social pressure which causes stress. Table 5.32 shows examples of participants' comments regarding this theme, which is more evident in the participants' comments on Cooperation and Social Learning.

Regarding Cooperation, 3% of the individualist participants, compared with 0% of the collectivist participants, commented that they would not want to be socially pressured to engage in physical activity as a result of seeing or being notified of the progress of their partner. For example, P104 commented that "*[w]hile the group goal setting is unique and interesting, I personally would not use an app with this feature.* ***The social pressure to reach that goal would only increase my stress level.***" Similarly, P33 commented that "***I would not like the pressure of affecting someone else's bonus.*** *I wouldn't do this.*" Evidently, this individualist participant did not want her inability to achieve her part of a collective goal to affect the collective reward she and her partner might be getting for achieving their goal. For her, this awareness and being accountable to her partner may be too much pressure for her to handle. This finding partly explains why individualist users, in general, are less likely to be receptive to Cooperation than collectivist users.

Moreover, similar concerns are expressed by both cultural groups regarding Social Learning. In fact, all of the participants that expressed concerns about social pressure said that they would not use a fitness app that supports social learning due to the social pressure it fosters. P104 (an individualist participant) commented, "*The social element is more convincing, but also* ***puts an increase on social pressure to complete goals. For this reason I would not use the app.***" Similarly, P206 (a collectivist participant) commented, "*for me if the app has this feature i will drop the app, as* ***i don[']t need pressure from friends and family is achieving my goals.***"

SW11. Users do not like sharing goals and progress with others. The eleventh reason why users are unlikely to be receptive to the social features of PHA is that they do not like sharing their physical-activity data with others, especially on social media, due to their concern with privacy and the belief that physical activity is personal. As shown in Table 5.33, this theme only applies to the individualist participants.

Specifically, 4%, 1% and 1% of the individualist participants expressed this concern regarding Social Learning, Cooperation and Social Comparison, respectively. For example, regarding Social Learning, P10 commented that "*Again,* ***I'm not one to share my goals.***" Similarly, P165 commented outright that "***I wouldn't share my data*** *or want to know how well or bad someone else is doing.*" This qualitative finding (individualist users not wanting to share their physical-activity data with others) is partly the reason why the individualist participants in the quantitative study (Table 5.3) are less likely to be receptive to Cooperation and Social Learning than the collectivist participants.

SW12. Comparison/competition should be with self and not others. The twelfth reason why users are unlikely to be receptive to the social features of a PHA is that they believe that comparison and competition should be with oneself and not others. As shown in Table 5.34, this theme is only applicable to the individualist group regarding Competition (3%) and Social Comparison (1%).

Regarding Social Comparison, P14 commented that "***I prefer to compare myself only [t]o my own progress.***" Moreover, regarding Competition, P150 commented that "***I feel we are better off comparing ourselves to ONLY ourselves*** *- otherwise we might not feel so great being at the bottom of the list.*" P150, in particular, seemed to be afraid of seeing herself at the bottom of a leaderboard; thus, she would rather compare her current with previous performance.

SW13. Not measuring up to others may cause a feeling of failure, guilt or shame. The thirteenth reason why users are unlikely to be receptive to the social features of a PHA is that they believe that not measuring up to others may cause a feeling of failure, guilt or shame. This could be as a result seeing oneself lagging behind or not meeting one's part of the bargain (collective goal) in a collaborative setting. Table 5.35 shows most of the participants' comments regarding this theme, which is only evident in the individualist participants' comments regarding Cooperation (1%) and Social Learning (2%).

Regarding Cooperation, P147 commented that "*[i]f my team member valued the points,* ***I would feel bad about causing us not to meet targets and earn points.***" Moreover, regarding Social Learning, P141 commented, "*Comparing myself to others would lik[el]y de-motivate me,* ***[I] would start thinking I suck compared to [K]im..etc.***" Apart from the feeling guilt or shame, P141 added that she would be likely demotivated if she was not performing as well as the person she was comparing herself with.

5.9.4 Summary of Findings

I provide a summary of the main findings of S2c. The thematic analysis of particpants' comments shows that some users, regardless of culture, are receptive to the four social features, while others are non-receptive. The five main reasons behind users' receptiveness to the four social features include the following:

1. Social features encourage, challenge and/or motivate people to engage in exercise behavior;
2. Users like/enjoy comparison/competition with others;
3. Users' competitive nature makes them want to engage with others;
4. Cooperating or competing with others is fun and interesting; and
5. Users do not want to be the reason for the failure of their group.

On the other hand, the five main reasons behind users' non-receptiveness to the four social features include the following:

1. Users do not like comparison and/or competition with others;
2. Users are indifferent to others' exercise, goals and achievements;
3. Users do not like working with others in a group setting;

4. Comparison/competition could be demotivating and harmful; and
5. Users do not want to rely on others for achievement of goals/rewards.

Moreover, the thematic analysis of participants' comments shows there are cultural differences in users' receptiveness to the four social features. Table 5.36 shows the culture-specific overall percentage of favorable and unfavorable comments related to the teased-out drivers of users' receptiveness and non-receptiveness to the four social features. For each social feature and culture, it is calculated by deducting the percentage of participants that made unfavorable comments from the percentage of participants that made favorable comments. Overall, the individualist participants (-13.3%) are more receptive to the four social features than the collectivist participants (+14.1%). While the overall percentage polarity of favorable comments is negative for the individualist culture it is positive for the collectivist culture. This means, overall, 14.1% of the collectivist participants made positive comments (related to the respective themes) about the four social features, while 13.3% of the individualist participants made negative comments.

Specifically, the polarity of the overall percentage of favorable comments regarding Cooperation, Social Learning and Social Comparison is positive for the collectivist group (28% , 14% and 5%, respectively), but negative for the individualist group (-18% , -13% and -26%, respectively). However, the polarity regarding Competition is positive for the collectivist group (9%) and individualist group (3%). These findings suggest that the four social features (especially Cooperation, Social Learning and Social Comparison) are more likely to be effective in motivating behavior change in the collectivist culture than in the individualist culture.

Table 5.36: Overall percentage of favorable participants' comments on social features in each culture.

	COOP		**SLEARN**		**SCOMP**		**CMPT**		**All Social Features**	
	C	**I**	**C**	**I**	**C**	**I**	**C**	**I**	**C**	**I**
# of participants	67	189	67	189	67	189	67	189	268	756
% of favorable comments	32	20	23	24	15	18	20	33	22.6	24
% of unfavorable comments	4	38	9	37	10	44	11	30	8.5	37.3
Overall % of favorable comments	28	-18	14	-13	5	-26	9	3	14.1	-13.3

5.10 Social Persuasive Features: Triangulation of Quantitative Findings from S2a and Qualitative Findings from S2c

This section focuses on the triangulation of the qualitative and quantitative findings with respect to the target audience's receptiveness to social features. Table 5.37 shows the quantitative results (overall mean rating and ranking scores) from S2a and the qualitative results (overall percentage of favorable comments) from S2c with regard to both social features. Overall, regardless of the study method (quantitative rating, quantitative ranking or qualitative comments), the collectivist culture (4.7/7, 3.3/6 and 14.1%, respectively) is more likely to be receptive to the social features of a PHA than the individualist culture (3.7/7, 3.0/6 and -13.3%, respectively). The cultural difference in users' receptiveness to the four social features is more evident with respect to Cooperation, Social Learning and Social Comparison, where the numerical/percentage cultural differences are (1.5/7, 0.6/6 and 46%, respectively), (0.6/7, 0.7/6 and 27%, respectively) and (1.0/7, 0.2/. and 31%, respectively), respectively.

Table 5.37: Triangulating qualitative findings from S2c with quantitative findings from S2a with respect to users' receptiveness to social features. Mean Rating = 4, Mean Ranking = 3.5.

	COOP		**SLEARN**		**SCOMP**		**CMPT**		**All Social Features**	
	C	**I**	**C**	**I**	**C**	**I**	**C**	**I**	**C**	**I**
# of participants	67	189	67	189	67	189	67	189	268	756
Average Rating (1-7 scale)	4.9	3.4	4.4	3.8	4.6	3.6	5	4	4.7	3.7
Average Ranking (1-6 scale)	3.5	2.9	3.6	2.9	2.9	2.7	3.2	3.5	3.3	3
Overall % of favorable comments	28%	-18%	14%	-13%	5%	-26%	9%	3%	14.1%	-13.3%

Specifically, in the quantitative analysis, I showed that the collectivist participants rated all three social features significantly higher than the individualist participants ($p < 0.05$). In particular, the collectivist participants ranked Cooperation and Social Learning significantly and Social Comparison numerically higher than the individualist participants ($p < 0.05$) as evident in Table 5.37. These findings (quantitative-based cultural differences) with regard to all three social features are replicated based on the qualitative method.

Regarding all three social features, the overall percentage of favorable comments provided by the collectivist participants is remarkably higher than that provided by the individualist participants: Cooperation (collectivist: 28%, individualist: -18%), Social Learning (collectivist: 14%, individualist: -13 %) and Social Comparison (collectivist: 5%, individualist: -26%). Regarding Competition, due to the mixed findings and the non-significant difference between the individualist and collectivist cultures based on its ranking (3.2/6 and 3.5/6, respectively) and overall percentage of favorable comments (9% and 3%, respectively), further studies need to be conducted, especially in the field. This will help to determine which of the two types of culture that will be more receptive to Competition.

Based on the triangulation of the quantitative and qualitative results from S2a, S2b and S2c, I summarize the key findings of the current study as follows:

1. Social features such as Cooperation, Social Learning and Social Comparison are more likely to be effective in motivating behavior change in the collectivist culture than in the individualist culture.

2. In the collectivist culture, all four social features are likely to be effective in motivating behavior change. However, in PHA design, Cooperation, Social Learning and Social Comparison should be given priority over Competition.

3. In the individualist culture, only Competition is likely to be effective in motivating behavior change. Thus, in PHA design, Competition should be given priority over the other three social features.

4. Thus, in a one-size-fits-all social PHA, Competition should be given priority over the other three social features.

5.11 Conclusion and Contributions

In this chapter, I presented the results of three investigations (S2a, S2b and S2c), which provide answers to RQ2, "***What are the persuasion profiles of the target audience in the application domain and how are they moderated by culture?***." The chapter and study (S2) makes a number of contributions to the PT literature. The main contribution of the study is that it employed a mixed-method approach to show and confirm the level of receptiveness of collectivist and individualist users to six commonly employed persuasive strategies/features employed in a PHA. Specifically, using quantitative and qualitative methods, it showed that individualist users are more likely to be receptive to personal features such as Goal-Setting/Self-Monitoring, while collectivist users are more likely to be receptive to social features such as Cooperation, Social Learning and Social Comparison. To the best of my knowledge, this study, in cross-cultural comparative studies in PT, is the first to triangulate quantitative and qualitative results successfully by using Canada/United States (individualist culture) and Nigeria (collectivist culture) as a case study. Secondly, the current findings in the application domain (S2) confirm those in the theory domain (S1). Specifically, in the theory domain (S1), I found that Self-Efficacy and Self-Regulation are significant social-cognitive determinants of Physical Activity in the individualist culture. These findings are validated in the application domain. Based on the mixed-method analysis in S2a and S2b, I found that the individualist culture is receptive to personal features such as Goal-Setting/Self-Monitoring. Moreover, in the theory domain (S1), I found that Social Support is a stronger social-cognitive determinant of Physical Activity in the collectivist culture than in the individualist culture. This finding is validated in the application domain. Based on the mixed-method analysis in S2a and S2c, I found that the collectivist culture is more likely to be receptive to social features such as Cooperation, Social Learning and Social Comparison than the individualist culture.

5.12 Limitations and Future Work

The main limitation of this study is that its findings are based on self-report and participants' perceptions about the persuasive features of a PHA illustrated on storyboards. Thus, the generalizability of the findings to the context of a real-life application may be threatened. However, the mixed-method results I presented in this study provide useful insights into what persuasive strategies are likely to be effective in each culture in motivating behavior change in the field. In Chapter 9, I investigate the generalizability of the current culture-specific findings to the field setting using an actual PHA.

6 Persuasive Technology Adoption Model

This chapter focuses on the fourth step of the EMVE-DeCK Framework, which is the third study of the dissertation. The study (S3) is situated in the EMVE-DeCK Framework as shown in Figure 6.1. Prior to developing a persuasive health application (PHA) to change behavior, there is a need to understand the Persuasive Technology Adoption Model of the target audience. This chapter presents four investigations. The first and second investigations (S3a and S3b), in the context of Persuasive Technology Acceptance Model (PTAM), examine the user experience (UX) design attributes that explain the *acceptance* of a PHA using a quantitative and qualitative approach, respectively. Moreover, the third and fourth investigations (S3c and S3d), in the context of Persuasive Technology Use Model (PTUM), examine the key persuasive design and application features that explain the *use* of a PHA using a quantitative and qualitative approach, respectively.

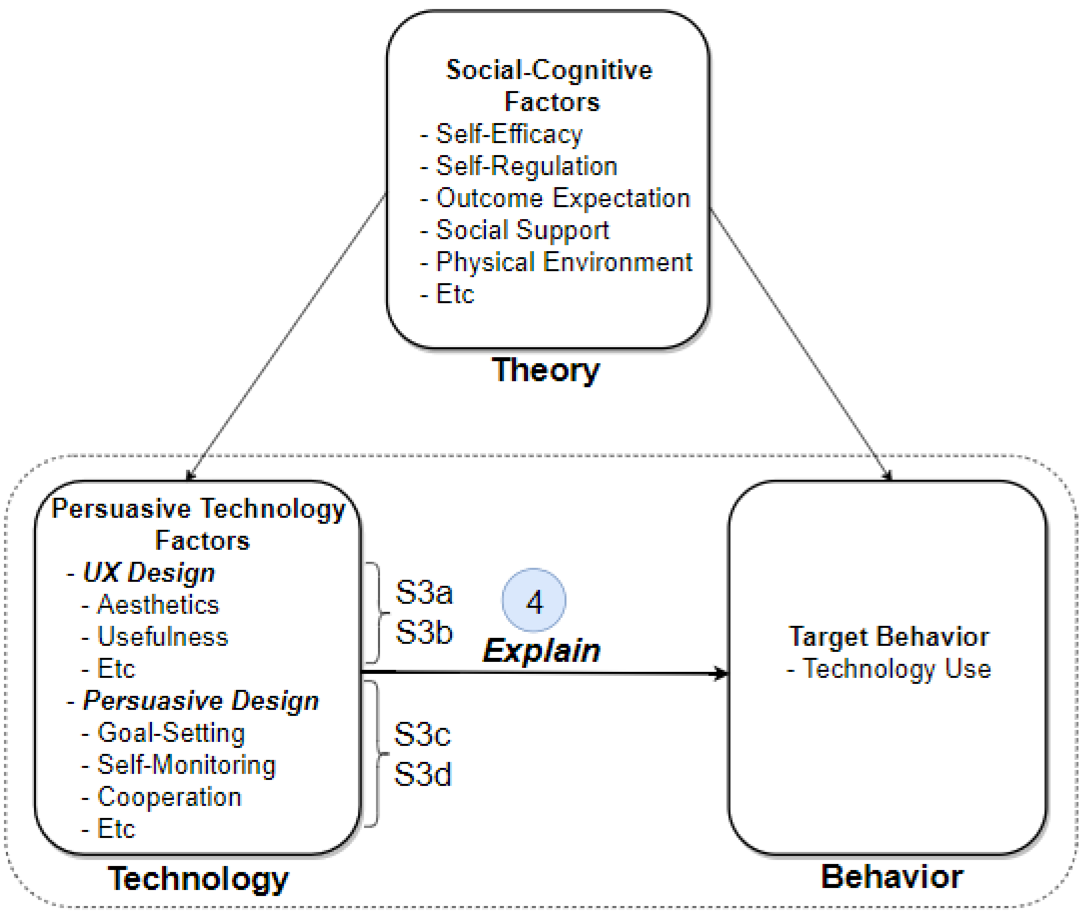

Figure 6.1: Situating the persuasive technology adoption study in the EMVE-DeCK Framework

6.1 Motivation

Fitness applications have permeated the lives of millions of people around the world as a result of the need for humans to be and remain healthy physically and mentally, especially, to slow down the incidence of aging. In particular, fitness applications (e.g., Runtastic, MyFitnessPal, Strava, Fitbit, Fitocracy, etc. [25]) have become popular because of the rising sedentary lifestyles, often resulting in overweight, obesity and non-communicable diseases (NCDs) such as type-2 diabetes, hypertension and stroke [4]. Other key drivers of the fitness app industry include increased number of memberships of gyms and health clubs, increased fitness app demand and mobile-device penetration in developing countries, increased availability of high-speed internet connections and services, etc. [213]. Hence, the ever-growing impact of free and commercial mobile health applications as a tool and medium for informing, educating and motivating users to engage in regular physical activity cannot be underestimated [15]. For example, the global market size for fitness apps is predicted to surpass US $14.7 billion by 2026 [214]. Over the years, the growing global market size has brought about a fierce competition among fitness app vendors, who are competing each day to increase profitability by increasing their market share [215]. Often, to make fitness applications more effective in motivating behavior change, designers often equip them with persuasive features such as Goal-Setting, Self-Monitoring, etc. [25]. Moreover, they are equipped with social features such as Cooperation, Competition, Social Learning, etc., in an attempt to utilize the power of social influence to motivate behavior change. However, on the market, prior to potential users deciding to adopt (accept and use) a fitness application, they often base their evaluation and judgment on the perceived UX design attributes of such an application [25][60][216], with *perceived usefulness* encapsulating the persuasive (design) features. Hence, it becomes pertinent in the health domain to understand the key UX and persuasive design drivers of the adoption of fitness applications, which are gaining traction in many countries around the world. Studying the perceptions of the target users prior to implementing a health application is considered a wise design decision. Particularly, the study of developing countries is essential given that their acceptance of health applications is relatively low [217].

6.2 Related Work

Few studies have investigated how and why users adopt PHAs (such as fitness applications) aimed at motivating physical activity. Kwak [218] examined the factors that influence the acceptance of a mobile fitness application among college students in the United States. The author found that *perceived usefulness* is the strongest determinant of the *intention to use* a mobile fitness application. The author also found that *perceived usability* is a determinant as well, but *perceived enjoyment* is not. Similarly, Beldad and Hegner [219] investigated the most important factors that influence the continued use of a fitness application among the German population. The authors found that *perceived usability* and *perceived usefulness*, but not *perceived trust*, influence users' *intention to continue using* a fitness app. Liao [220] examined the factors that influence the downloading of fitness applications from online stores among college students in the United States. The author found that both *perceived usefulness* and *perceived usability* are significant determinants of users' *intention to download* fitness apps. Moreover, Nunes et al. [221] investigated the acceptance of mobile health apps among Psychology college students in Portugal. They found that *performance expectancy*, which is moderated by age and smartphone experience, influences the *intention to use* a mobile health app.

The related work shows that *perceived usefulness* and *perceived usability* are the strongest determinants of the *intention to use* a fitness app. However, most of the studies did not consider *perceived aesthetics* and *perceived credibility* in their extended TAM. Yet, both constructs are common perceived UX design attributes that may influence fitness app acceptance as in the case of websites [216][222][223]. Secondly, none of the studies investigated the role *perceived persuasiveness* plays in the TAM. Although Lehto et al. [109] and Drozd et al. [110] incorporated *perceived persuasiveness* in their TAM model, the persuasive application they investigated was not a fitness app. Moreover, they did not investigate the influence of culture. Thirdly, most of the studies used convenience samples such as college students. Fourthly, the target audiences are mostly from individualist countries based in North America and Europe. As evident in the systematic review [224], very little attention has been paid to the collectivist countries on the African continent and how culture influences the UX design determinants of the acceptance of a PHA [217]. Apart from UX design factors, there are limited studies that have examined: (1) the persuasive design features (e.g., Goal-Setting/Self-Monitoring, Reward, Cooperation, etc.) that explain the use of a PHA, (2) the key features of a PHA (supportive and persuasive) that users care about using a qualitative approach, and (3) the moderating effect of culture. The current study intends to bridge these gaps in the extant literature using quantitative and qualitative approaches that are amenable to triangulation to increase the consistency and reliability of findings.

6.3 Study Objective

The main objective of S3 is to answer the third research question of the dissertation (RQ3), "***What methods and/or models can we use to understand the adoption of a new technology-based intervention by the target audience?***." This research question is broken down into the following four subquestions:

RQ3a. Using the PTAM[1], which of the common UX design attributes are the strongest determinants of the acceptance of a PHA and how are they moderated by culture?

RQ3b. What are the prominent UX design attributes of a PHA that grab users' attention and how are they moderated by culture?

RQ3c. Using the PTUM, which of the common persuasive design features are the strongest determinants of the use of a PHA and how are they moderated by culture?

RQ3d. What are the key features of a PHA users care about and how are they moderated by culture?

[1] I chose to use TAM because it and its derivatives are among the most useful models employed in explaining health information system acceptance [217][224][225].

6.3.1 Study Method

To answer the research questions in the foregoing subsection, I employed: (1) a fitness application prototype which mocked up a proposed PHA; and (2) storyboards which mocked up possible persuasive features the proposed PHA will support. The prototype (Figure 6.2[2]) depicted some of the basic features of fitness applications on the market, e.g., Goal-Setting and Self-Monitoring. Moreover, the storyboards implemented six commonly employed persuasive features in fitness applications on the market: two personal features (Goal-Setting/Self-Monitoring and Reward) and four social features (Cooperation, Social Learning, Competition and Social Comparison). Figure 6.3 and Figure 6.4 show the storyboards for Reward and Cooperation, respectively. Moreover, Appendix B shows the storyboards for Competition (Figure B.3) and Social Comparison (Figure B.4). The storyboards for Goal-Setting/Self-Monitoring (Figure 5.2) and Social Learning (Figure 5.3) were presented in Chapter 5 in the context of users' receptiveness to persuasive strategies.

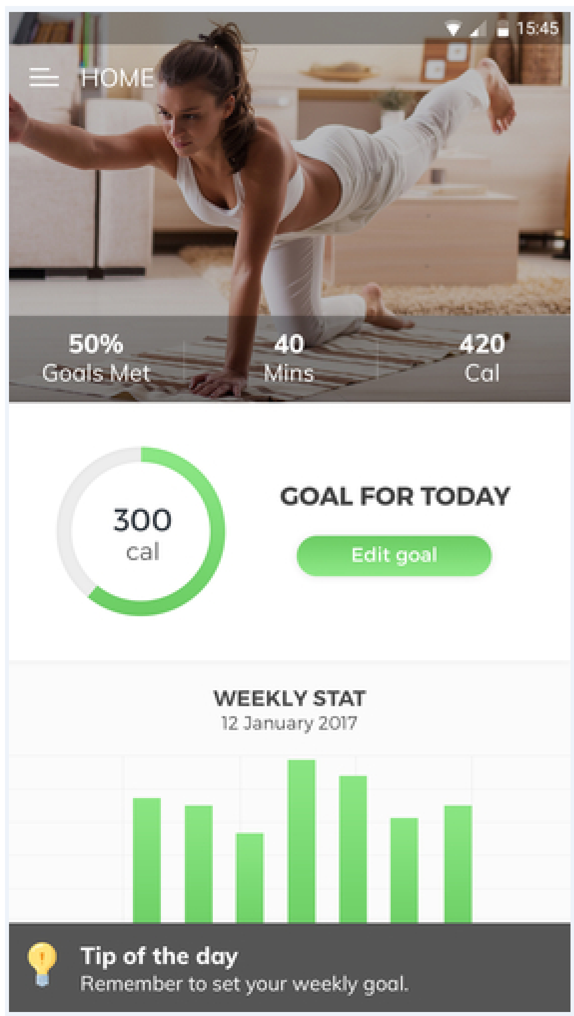

Figure 6.2: Mobile fitness application prototype for encouraging home-based exercise behavior

[2]The behavior model on the homepage is taken from https://www.awaken.com/2016/09/home-yoga-practice-questions/

Figure 6.3: Storyboard illustrating reward persuasive feature

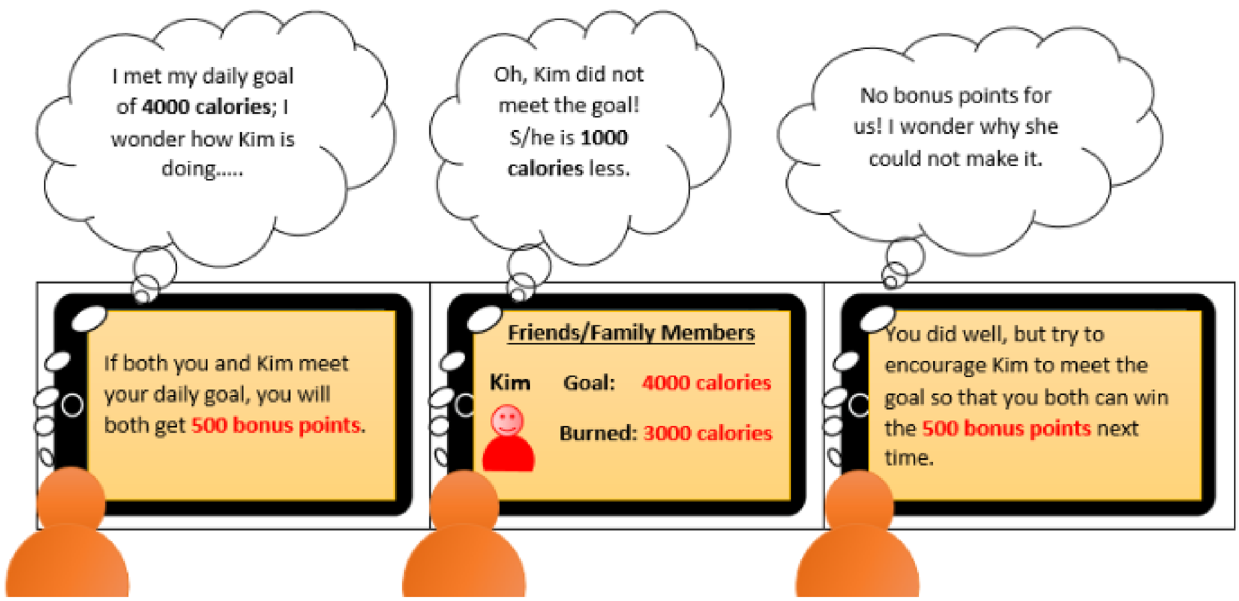

Figure 6.4: Storyboard illustrating cooperation persuasive feature

6.3.2 Study Design

Th study employed a mixed-method approach (quantitative and qualitative analyses) and triangulation technique to address the UX-design and application-feature requirements of the target users and the moderating effect of culture. Four investigations were carried out to address the four subquestions. Each of the four investigations are briefly explained as follows:

1. S3a provides answers to RQ3a using a quantitative approach. It investigates the strongest UX design attributes that influence the target users' acceptance of a PHA and the moderating effect of culture.

2. S3b provides answers to RQ3b using a qualitative approach. It investigates the most prominent UX design attributes of a PHA that grab the target users' attention and the moderating effect of culture.

3. S3c provides answers to RQ3c using a quantitative approach. It investigates the most important persuasive features that influence the target users' use of a PHA and the moderating effect of culture.

4. S3d provides answers to RQ3d using a qualitative approach. It investigates the key features of a PHA that the target users care about and the moderating effect of culture.

6.3.3 Data Collection

The study (online survey) was submitted to the University of Saskatchewan Behavioral Research Ethics Board for review. After approval, it was posted on the Amazon Mechanical Turk (MTurk) for participants resident in North America (Canada and United States) to take part anonymously. Moreover, it was sent via email to participants resident in Nigeria for anonymous participation. The Nigerian group of participants were recruited via email because many of them were not on MTurk. In appreciation of their time, each participant from Canada/United States was compensated with US $1.50. However, each participant from Nigeria was compensated with a N200 Nigerian phone-credit card. See Appendix B for the consent form.

6.3.4 Participants

Over 300 participants from Canada/United States and Nigeria took part in the study. Table 5.2 shows the demographic information of the valid participants (n = 256) after data cleaning. Specifically, 189 participants from Canada/United States (individualist culture) and 67 participants from Nigeria (collectivist culture) were validated and employed in carrying out the final data analysis.

6.3.5 Measurement Instruments

Both quantitative and qualitative measures were used in addressing the research questions. In this section, I briefly discuss the measurement instruments for each research question.

S3a Quantitative Measure

Regarding RQ3a quantitative scales were used to measure the UX design attributes and their related constructs. Table 6.1 shows the measurement scales for the four UX design attributes of interest and related constructs. First, the study participants were asked, based on first impression, to rate the PHA prototype (shown in Figure 6.2) in terms of *perceived aesthetics*, *perceived usability*, *perceived credibility*, *perceived usefulness* and *perceived persuasiveness* (a proxy for attitude towards the application). All of the items from each of the five constructs were combined and randomized to each of the participants. Lastly, the participants were asked to rate their *intention to use* the PHA prototype if it was deployed in real life. All of the constructs employed a 7-point Likert scale ranging from "Strongly Disagree (1)" to "Strongly Agree (7)."

Table 6.1: Empirical scales measuring UX design constructs and intention to use. They are adapted from the cited authors. The first and last three items in perceived aesthetics are lower-order constructs (classical and expressive dimensions, respectively).

Construct	Items in Scale
Perceived Aesthetics [226][227]	1. The app is visual.
	2. The app is clean.
	3. The app is pleasant.
	4. The app is fascinating.
	5. The app is sophisticated.
	6. The app is creative.
Perceived Usability [227][228]	1. The app is easy to use.
	2. The app is convenient to use.
	3. The app is easy to navigate.
	4. The app has a clear design.
	5. The app has easy orientation.
Perceived Credibility [229]	The app is credible.
Perceived Usefulness [106]	1. The app will help me improve my exercise performance.
	2. The app will help me accomplish my exercise goals easily.
	3. The app will be useful in my exercise.
	4. The app will make it easier to reach my exercise goals.
Perceived Persuasiveness [109][206]	1. The app would influence me.
	2. The app would be convincing.
	3. The app would be personally relevant for me.
	4. The app would make me reconsider my physical activity habits.
Intention to Use [109]	Assuming the app was deployed in real life, I predict that I will use it if I have the opportunity.

S3b Qualitative Measure

To answer RQ3b, a qualitative measure was employed. Regarding the PHA prototype (Figure 6.2), the study participants were asked the open question, "*Please comment on your first impression about the app.*"

S3c Quantitative Measure

Regarding RQ3c, quantitative scales were used to measure the *perceived persuasiveness* of the six persuasive design features illustrated on the storyboards. Table 6.2 shows the measurement scale for each of the empirical constructs of interest. Each construct was measured on a 7-point Likert scale ranging from "Strongly Disagree (1)" to "Strongly Agree (7)." Specifically, the study participants were asked to rate each of the storyboards (e.g., Figure 6.4) in terms of its *perceived persuasiveness*. At the end, they were asked to rate their *intention to use* the fitness app (equipped with the illustrated persuasive features) if it was deployed in real life.

Table 6.2: Empirical scales measuring persuasive each of the six features illustrated on a storyboard and intention to use. They were adapted from the cited studies.

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Construct	Items in Scale
	Imagine that you are using the Homex App presented in the storyboard above to track your physical activity, to what extent do you agree with the following statements:
Perceived Persuasiveness [109][206]	1. This feature of the app would influence me.
	2. This feature of the app would be convincing.
	3. This feature of the app would be personally relevant for me.
	4. This feature of the app would make me reconsider my physical activity habits.
Intention to Use [109]	Assuming the app, together with the various features, described earlier on, would be available to me, I predict that I will use it.

S3d Qualitative Measure

To answer RQ3d, a qualitative measure was employed. Regarding the PHA prototype (Figure 6.2), the study participants were asked the open question, "*Please enter here [textbox provided] one key feature you would expect the app to have if you were to use it.*"

6.4 S3a: Investigation of the UX Design Determinants of the Adoption of a PHA among the Target Audience and the Moderating Effect of Culture: a Quantitative Approach

UX is a complex concept in Human-Computer Interaction (HCI), thus there is no consensus with regard to its definition. However, there is a consensus among HCI researchers that the UX should not be simply equated with the usability construct [230][231]. That said, Følstad and Rolfsen [232] classified the UX body of knowledge into three camps relating to usability: (1) UX encompasses usability; (2) UX complements usability; and (3) UX is one of many components that constitute usability.

The first camp views UX as a broad concept comprising usability among other things. For example, Petre et al. [233], in the context of e-commerce websites, viewed UX as the total customer experience which extends beyond the interaction with e-commerce products. It includes the delivery of the products, consumption of the products and services, and post-sales support, all of which influence the perceptions of value and service quality and ultimately customer loyalty. The second camp views UX as an addition to the traditional notion of usability. Researchers such as Hassenzahl and Tractinsky [234] summarized UX research as a body of work that focuses on the emotional, experiential, and non-task-oriented aspects of HCI. Finally, the third camp views UX as one of the components of usability which include effectiveness and efficiency [232] .

However, owing to the advancement of HCI design beyond usable systems in recent time, with designers focusing on systems that are appealing, enjoyable and entertaining (e.g., games), the definition of UX has been broadened to encompass the new dimension [231]. In particular, Law et al. [235] argued that the definition of UX should take a more holistic, unified approach, which encompasses the pragmatic as well as the hedonic aspects of HCI system design. The pragmatic aspects refer to the utilitarian/productive components of a HCI system design, which include usability and usefulness. On the other hand, the hedonic aspects refer to the hedonic/affective components, which include beauty and enjoyment. Hence, to cover both aspects, UX can be defined as the overall experience users derive from using or interacting with a HCI system, including how easy or pleasing it is to use the system. It is a subjective concept, making the actual experiences with HCI systems differing considerably among users due to the different individual standards and from the experiences intended by the designer [236].

In the context of the current investigation carried out at the level of perception, UX design attributes can be described as the perceived hedonic and pragmatic features of a persuasive system that help users to decide whether they will embrace it or not. Such attributes include *perceived aesthetics*, *perceived usability*, *perceived credibility*, *perceived usefulness*, etc. This investigation[3] sets out to understand the role these attributes play in the acceptance of a PHA such as a fitness app and the moderating effect of culture.

6.4.1 Research Questions

Formally, this investigation aims to address the research question (RQ3a), "*Using the PTAM, which of the common UX design attributes are the strongest determinants of the acceptance of a PHA and how are they moderated by culture?*" The research question is broken down as follows:

RQ3a-i. Which of the four commonly known UX design attributes is/are the strongest determinants of the *intention to use* a PHA?

RQ3a-ii. Does the inclusion of *perceived persuasiveness* in the PTAM improve the model?

RQ3a-iii. Is the effect of *perceived usefulness* on *intention to use* mediated by *perceived persuasiveness*?

RQ3a-iv. Are the interrelationships among the UX design constructs in the PTAM moderated by culture?

6.4.2 Research Model and Hypotheses

To answer the four subquestions, I formulated a number of hypotheses based on the existing literature on the extended TAM [58][109][110]. All of the hypotheses are depicted in the research model shown in Figure 6.5. See Table 6.1 for the quantitative measures of the constructs in the model.

[3]This investigation is originally published in Frontiers. The results and other parts of the writeup are reproduced verbatim or adapted from the original publication [237].

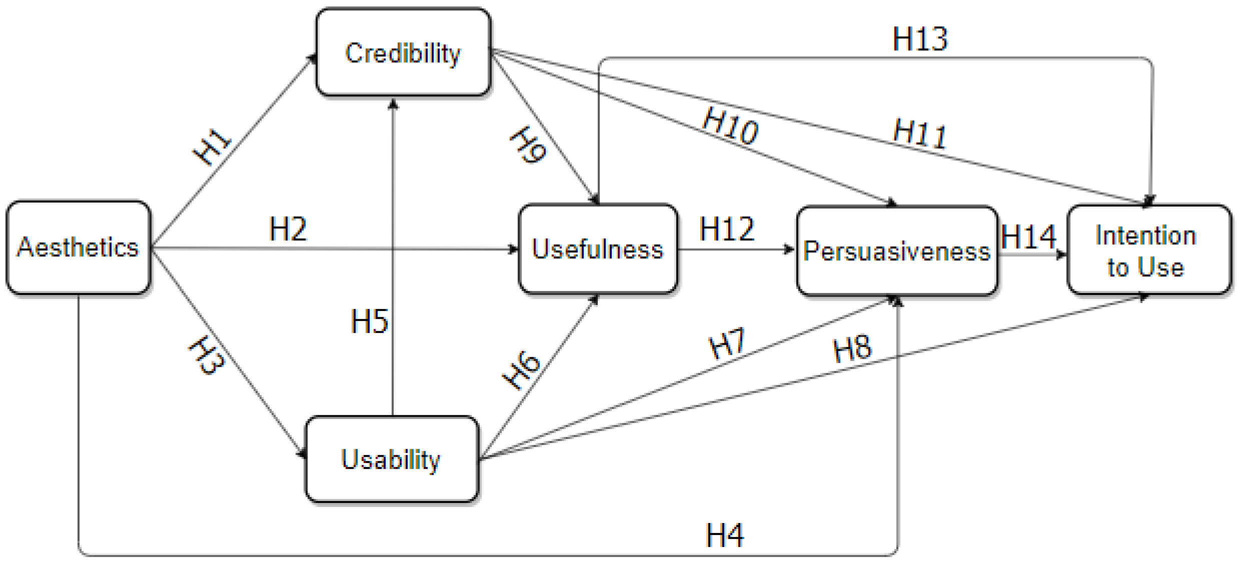

Figure 6.5: Hypothesized model of persuasive technology acceptance

Hypotheses with Perceived Aesthetics as an Antecedent (H1-H4)

In PT, *perceived aesthetics* is considered an important factor in the persuasion process, which has the potential to influence the adoption of a proposed information system among its target users [21][61]. Prior research has found that the more *aesthetic* (i.e., *attractive*) a persuasive system (e.g., a website) is, the more likely users are to perceive it as *usable*, *credible*, *useful* and *persuasive*. For example, in a study of the determinants of the *perceived credibility* of a mobile website in the tourism domain, Oyibo et al. [119][238] found that, regardless of culture and gender, the higher potential users perceived the mobile website design to be aesthetic, the higher they perceived as credible. Hence, in the current study, I hypothesize that the higher the study participants perceive the fitness application to be *aesthetic*, the more likely they will perceive it as *credible* (H1). Similarly, in a study of the TAM for a Dutch generic web portal, Van der Heijden [58] found that the higher the actual users of the portal perceived it as *aesthetic*, the higher they perceived it *easy to use* and *useful*. Therefore, in the current investigation, I hypothesize that the higher the potential users of a fitness application perceive it to be *aesthetic*, the higher they will perceive it as *useful* (H2) and *usable* (H3). Finally, in a study of a health application modeling bodyweight exercise behavior, Oyibo et al. [239] found that the higher potential users perceived it to be *classically* and *expressively aesthetic*, the higher they viewed the app as *persuasive*. As a result, in the present study, I hypothesize that the higher the study participants perceived the fitness application to be *aesthetic*, the higher they will perceive it as a *persuasive*.

Hypotheses with Perceived Usability as an Antecedent (H5-H8)

In the traditional TAM, *perceived usability* (aka *perceived ease of use*) is found to be one of the two most important determinants of the acceptance of information systems [57]. *Perceived usability* is closely linked to the concept of perceived self-efficacy, which is the belief in one's ability to perform a given behavior. In behavioral theories such as SCT [57][163], perceived self-efficacy has been found to be one of the strongest determinants of health behavior such as physical activity. Similarly, in the TAM, *perceived usability*, which entails the perceived level of effort required to interact with a system, has been found to be a strong determinant of the usage of an information system. Apart from system usage, *perceived usability* is associated with UX design attributes such as *perceived credibility*, *perceived usefulness* and *perceived persuasiveness*. Oyibo et al. [119][238] found that the higher users perceived a mobile website to be usable, the higher they perceived it as credible. Moreover, Van der Heijden [58] found that the higher users perceived a generic web portal to be usable, the higher they perceived it to be useful and their *intention to use* it. Finally, Oinas-Kukkonen and Harjumaa [61] postulated that a persuasive system that is easy to use is more likely to persuade users than a persuasive system that is difficult to use. Therefore, in the current investigation, I hypothesize that the higher the study participants perceive a fitness application to be *usable*, the higher they will perceive it as *credible* (H5), *useful* (H6), *persuasive* (H7) and have a positive *intention to use* it (H8).

Hypotheses with Perceived Credibility as an Antecedent (H9-H11)

In the extended TAM, *perceived credibility* has been found to be an important factor in the information technology adoption process. Marton and Choo [240] found that the *perceived credibility* of health information sought on the web significantly (positively) influenced its *perceived usefulness* and *attitude towards use*. Moreover, Amin et al. [241] and Luarn and Lin [242] found that the higher users perceived a banking system to be *credible*, the higher became their *intention to use* the system. Based on these findings, in the current investigation, I hypothesize that the higher potential users perceive a fitness application to be *credible*, the higher they will find it *useful* (H9), *persuasive* (H10) and have a positive *intention to use* it (H11).

Hypothesis with Perceived Usefulness as an Antecedent (H12-H13)

In the traditional TAM, *perceived usefulness* is considered the most important determinant of the *intention to use* an information system [57]. It is regarded as a cognition-based extrinsic motivator, which can be likened to the outcome-expectation construct in the SCT [66]. In persuasive systems design, Oinas-Kukkonen and Harjumaa [61] postulated that a persuasive system that is considered useful is more likely to persuade potential users than a system that is considered otherwise. Moreover, Van der Heijden [58] found that the higher the actual users of a generic web portal perceived it to be useful, the higher became their *intention to use* it. Thus, in the current study, I hypothesize that the higher potential users perceive a fitness application to be *useful*, the higher they will find it *persuasive* (H12) and have a positive *intention to use* it (H13).

Hypothesis with Perceived Persuasiveness as an Antecedent (H14)

In the extended TAM, Lehto et al. [109] and Drozd et al. [110] found that the higher users perceived behavior change support systems in the health domain to be persuasive, the higher became their *intention to use* such systems. Based on this finding, in the current study, I hypothesize that the *perceived persuasiveness* will positively influence the study participants' *intention to use* a PHA (such as a fitness app) aimed at motivating behavior change (H14).

Exploratory Approach

Due to the paucity of cross-cultural research in this area, I adopted an exploratory approach to investigate how the two cultures differ in their PTAM. Similarly, I used an exploratory approach to determine whether including *perceived persuasiveness* in the TAM will improve the model or not. Particularly, there has been a debate whether attitude (a proximal construct in the traditional TAM, replaced in the PTAM by *perceived persuasiveness*) should be retained or removed from the TAM. On one hand, some researchers [108][55] have argued that, to achieve a parsimonious model, attitude should be excluded from the TAM. On the other hand, other researchers (e.g., [58]) have provided empirical evidence to support its retention in the TAM. With regard to *perceived persuasiveness*, I argue that, whether it should be part of the PTAM or not may depend on the target population and the domain of interest. The current investigation will verify this hypothesis in the physical-activity domain.

6.4.3 Data Analysis and Results

I employed Partial Least Squares Path Modeling (PLSPM) [74] technique to uncover which of the relationships in the hypothesized model are statistically significant in each culture. In this section, I present the results of the path modeling, including the evaluation of the measurement models, the analysis of the structural models, adjusted R-squared analysis, total-effect analysis, mediation and multigroup analyses.

Evaluation of the Measurement Models

Prior to analyzing the culture-specific structural models, I assessed the measurement models to ensure that the preconditions were met [74][170]. The preconditions, their definitions and the overall results of the evaluation are shown in Table 6.3. They include indicator reliability, internal consistency reliability, convergent validity and discriminant validity. All four criteria were met as shown in Table 6.3. For example, regarding indicator reliability, the loading of the items on each construct in the culture-specific measurement models is greater than 0.7. Similalrly, regarding internal consistency reliability, the composite reliability criterion—Dillon-Goldstein's rho (ρ)—for each construct is greater than 0.7.

Structural Analysis of the Collectivist Model

Figure 6.6 shows the collectivist model. It is built using the collectivist sample (n = 67) and the "plspm" package in R. The goodness of fit (GOF) for the model is 84%, which is regarded as a large value in the PLSPM community [187]. This indicates that the collectivist model fits or explains its empirical data to a large degree.

Table 6.3: Evaluation of the measurement models in the PTAM for a PHA prototype [74][170][186]

Criterion	Definition	Evaluation Result
Indicator Reliability	It is the degree to which an indicator that measures a construct is reliable. Thus, it is defined as the variance of the indicator that is not accounted for by measurement error.	This criterion for each construct in the measurement models was measured using the outer loading metric, which was greater than 0.7 for each indicator.
Internal Consistency Reliability	It is a measure of the extent to which a set of indicators that measure a construct produces similar scores.	This criterion for each construct in the measurement models was evaluated using the composite reliability metric known as Dillon-Goldstein's rho (ρ), which was greater than 0.7 for each of the constructs.
Convergent Validity	It is a measure of how well the indicatores that measure a given construct are closely related.	This criterion was measured using the Average Variance Extracted (AVE) metric, which was greater than 0.5 for each construct in the measurement models.
Discriminant Validity	It is a measure of the extent to which the indicators that measure a given construct are unrelated to another construct in the measurement model.	This criterion was measured using the crossloading metric. In each of the measurement models, our result showed that no construct's indicator loaded higher on some other construct than the one it was designed to measure.

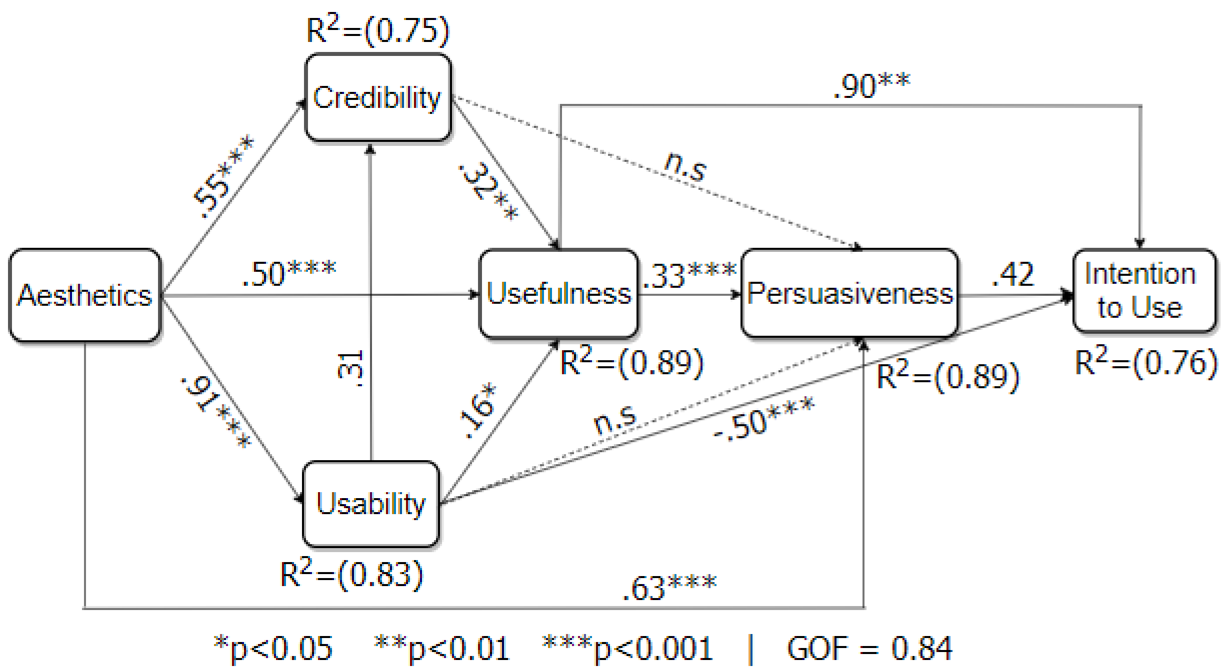

Figure 6.6: Collectivist persuasive technology acceptance model for a PHA prototype (relationship unshown or lableled "n.s" is a non-significant path coefficient excluded from the model when it was built)

Moreover, the coefficient of determination (R^2) of *intention to use* is 76%, which is regarded as high as well [74]. This indicates the exogenous constructs terminating in the target construct explain most of its variance. However, the R^2 of *perceived usefulness* and *perceived persuasiveness* is the highest in the model (89%). Regarding the path coefficients (β values), ten of the fourteen hypotheses are significant. The relationship between *perceived aesthetics* and *perceived usability* ($\beta = 0.91$, $p < 0.001$) is the strongest. The second strongest relationship, which is approximately equal to the strongest, is that between *perceived usefulness* and *intention to use* ($\beta = 0.90$, $p < 0.001$). The weakest of the significant relationships is between *perceived usability* and *perceived usefulness* ($\beta = 0.16$, $p < 0.05$). Specifically, there is a negative (inconsistent [243]) relationship between *perceived usability* and *intention to use* (β = -0.50, $p < 0.001$) in the collectivist model. I elaborate on this inconsistent relationship in the discussion section.

Structural Analysis of the Individualist Model

Figure 6.7 shows the individualist model. It is built using the individualist sample (n = 189). The GOF for the model is 72%, which is a large value. The R^2 of *intention to use* is 61%, which is a high value as that of the collectivist model. Specifically, *perceived persuasiveness* ($\beta = 0.66$, $p < 0.001$) and *perceived usefulness* ($\beta = 0.14$, $p < 0.05$) account for 61% of the variance of *intention to use*. However, the R^2 of *perceived persuasiveness* has the highest value (66%), with *perceived usefulness* ($\beta = 0.69$, $p < 0.001$) and *perceived aesthetics* ($\beta = 0.16$, $p < 0.05$) accounting for its variance. The R^2 values of *perceived usefulness* (62%) and *perceived usability* (62%) are in the second place. Lastly, as in the collectivist model, the relationship between *perceived aesthetics* and *perceived usability* ($\beta = 0.79$, $p < 0.001$) turns out to be the strongest.

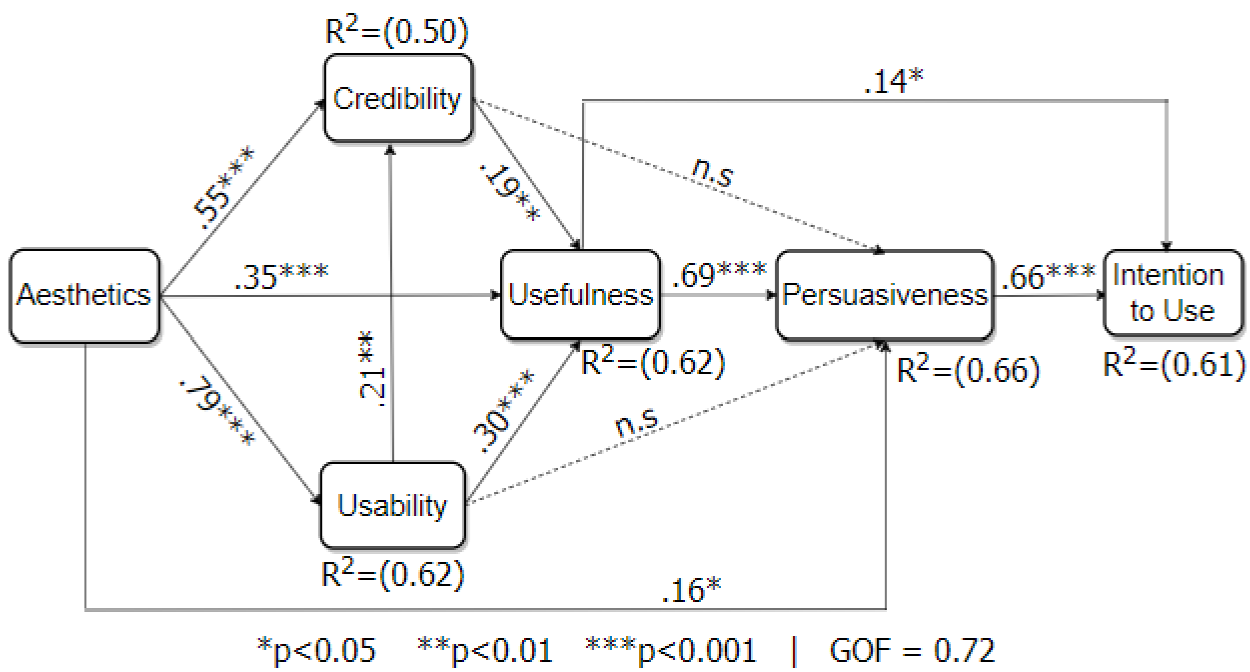

Figure 6.7: Individualist persuasive technology acceptance model for a PHA prototype (relationship unshown or lableled "n.s" is a non-significant path coefficient excluded from the model when it was built)

Effect Size and Cultural Difference

To uncover the magnitude of the effect of the two proximal constructs (*perceived usefulness* and *perceived persuasiveness*) on *intention to use* and the cultural difference, I conducted an effect-size analysis [72]. See Equation 4.2 on the effect-size calculation. The result (Table 6.4) shows that *perceived usefulness* has a large effect size on *intention to use* in the collectivist model (f^2 = 0.417), but no effect size in the individualist model (f^2 = -0.026). However, *perceived persuasiveness* has a large effect size on *intention to use* in the individualist model (f^2 = 0.359), but a non-significant small effect size in the collectivist model (f^2 = 0.083).

Table 6.4: Effect size of proximal constructs on intention to use. $f^2 = 0.02$: small, $f^2 = 0.15$: medium, $f^2 = 0.35$: large [72]. R^2_{inc} and R^2_{exc} are the coefficients of determination when the proximal construct is included and excluded from the model, respectively. The bold effect size is large.

	COL			IND		
Proximal Construct	R^2_{inc}	R^2_{exc}	f^2	R^2_{inc}	R^2_{exc}	f^2
Perceived Usefulness	0.76	0.66	**0.417**	0.61	0.62	-0.026
Perceived Persuasiveness	0.76	0.74	0.083	0.61	0.47	**0.359**

Adjusted R-Squared Analysis

To answer the second subquestion (RQ3a-ii), "*Does the inclusion of perceived persuasiveness in the PTAM improve the model?*," I built the culture-specific models with *perceived persuasiveness* excluded from the model. Table 6.5 shows the R^2 values for *intention to use* for the two versions of models. R^2_{inc} and R^2_{exc} are based on *perceived persuasiveness* included in and excluded from the respective models, respectively.

Table 6.5: R-squared adjust value for intention to use when perceived persuasiveness is included and excluded from the PTAM based on a PHA prototype. The bold value is greater than its counterpart.

	R^2		R^2_{Adj}	
	COL	**IND**	**COL**	**IND**
PERS Excluded	0.74	0.47	0.72	0.46
PERS Included	0.76	**0.61**	0.74	**0.60**

For the individualist model, the R^2 value increases by over 10% when *perceived persuasiveness* is included in the model. Specifically, the R^2 value increases from 47% to 61% (difference – 14%). However, for the collectivist model, the R^2 value of *intention to use* only increases by 2%: from 74% to 76%. These findings indicate that, in the individualist model, *perceived persuasiveness* is an important construct in the PTAM. However, in the collectivist model, *perceived persuasiveness* could be excluded from the model to make it more parsimonious. To confirm these findings, I computed the adjusted R-squared (R^2-adjust). The R^2-adjust is a metric that determines whether the inclusion of a predictor in a model improves it beyond what is expected by chance. Specifically, the R^2-adjust of *intention to use* for the individualist model increases substantially. That of the individualist model increases from 46% to 60%, while that of the collectivist model only increases a little (from 72% to 74%).

Mediation Analysis

To answer the third subquestion (RQ3a-iii), "*Is the effect of perceived usefulness on intention to use mediated by perceived persuasiveness?*," I carried out a mediation analysis to investigate whether *perceived persuasiveness* mediates the relationship between *perceived usefulness* and *intention to use*. The mediation analysis (see Table 6.6) is based on the metric called Variance Accounted For (VAF) by an indirect path. In the PTAM, the indirect path is: *perceived usefulness* $\rightarrow$ *perceived persuasiveness* $\rightarrow$ *intention to use*, while the direct path is: *perceived usefulness* $\rightarrow$ *intention to use*, with *perceived persuasiveness* excluded from the model.

Table 6.6: Variance accounted for by indirect path in the PTAM for a PHA protoypee. β_{dir} = direct path coefficient for USEF $\rightarrow$ ITU when PERS is excluded from the model. β_{indir} = indirect path coefficient for USEF $\rightarrow$ PERS $\rightarrow$ ITU. VAF = Variance Accounted For by indirect path. $VAF = 0.2$: partial mediation, $VAF = 0.8$: full mediation [72]. The bold value is greater than its counterpart.

	β_{indir}	β_{dir}	VAF
COL	0.14	0.96	0.13
IND	0.46	0.62	**0.43**

The VAF is the ratio of the indirect effect to the total effect (which is a sum of the direct and indirect effect of one construct on another). According to Hair et al. [72], a VAF less than 0.2, between 0.2 and 0.8, and above 0.8 indicates no mediation, partial mediation and full mediation, respectively. In the individualist model, when *perceived persuasiveness* is excluded from the model, the direct effect of *perceived usefulness* on *intention to use* increases from ($\beta = 0.14$, $p < 0.05$) to ($\beta = 0.62$, $p < 0.001$). The Variance Accounted For (VAF) by the indirect path is 0.43, indicating that *perceived persuasiveness* acts as a partial mediator of the direct effect of *perceived usefulness* on *intention to use* in the individualist model. On the other hand, in the collectivist model, when *perceived persuasiveness* is excluded from the model, the direct effect of *perceived usefulness* on *intention to use* is increases from ($\beta = 0.90$, $p < 0.001$) to ($\beta = 0.96$, $p < 0.001$). Despite that the relationship between *perceived persuasiveness* and *intention to use* is not statistically significant at $p < 0.05$ (a requirement for computing VAF), I computed the VAF all the same. The VAF value turned out to be 0.13 (less than 0.20), confirming that *perceived persuasiveness* does not mediate the direct effect of *perceived usefulness* on *intention to use* in the collectivist model.

Multigroup Analysis

To answer our fourth subquestion (RQ3a-iv), "*Are the interrelationships among the UX design constructs in the PTAM moderated by culture?*," I conducted a multigroup analysis based on culture [74][72]. The result (Table 6.7) shows that both cultures significantly differ in three relationships. Regarding the relationship between *perceived aesthetics* and *perceived usability*, the two cultures significantly differ ($p < 0.05$), with the relationship being stronger for the collectivist culture ($\beta = 0.91$, $p < 0.001$) than for the individualist culture ($\beta = 0.79$, $p < 0.001$). Second, the relationship between *perceived usability* and *intention to use* is significantly stronger ($p < 0.01$) for the collectivist culture (β = -0.50, $p < 0.001$) than the individualist culture (β = 0.01, $p = n.s$). Finally, the relationship between *perceived usefulness* and *intention to use* is significantly stronger ($p < 0.01$) in the collectivist model (β = 0.90, $p < 0.001$) than in the individualist model (β = 0.14, $p < 0.05$).

Table 6.7: Multigroup analysis showing where the collectivist and individualist cultures significantly differ (bold rows) in the PTAM relationships based on a PHA prototype. Asterisks represent statistical significant difference between both groups. "*" : $p < 0.05$, "**" : $p < 0.01$, "***" : $p < 0.001$.

Relationship	COL	IND	*p*-Value	Sig.
AEST → USAB	**0.91*** **	**0.79*** **	**0.0200**	**Yes**
AEST → CRED	0.55***	0.55***	0.2305	No
AEST → USEF	0.50***	0.35***	0.1865	No
AEST → PERS	0.63***	0.16*	0.1296	No
AEST → ITU	-0.05	-0.02	0.328	No
USAB → CRED	0.31	0.21**	0.4105	No
USAB → USEF	0.16*	0.30***	0.3821	No
USAB → PERS	0.01	-0.16	0.2813	No
USAB → ITU	**-0.50*** **	**0.01**	**0.0026**	**Yes**
CRED → USEF	0.32**	0.19**	0.4341	No
CRED → PERS	0.03	0.11	0.2612	No
CRED → ITU	0.06	-0.04	0.3054	No
USEF → PERS	0.33***	0.69***	0.2137	No
USEF → ITU	**0.90*** **	**0.14***	**0.0013**	**Yes**
PERS → ITU	0.42	0.66***	0.1533	No

Total Effect Analysis

To answer the first research question, I present the total effect of the perceived UX design constructs on *intention to use* as shown in Figure 6.8. In the collectivist model, *perceived usefulness* ($\beta_T = 1.04$ $p < 0.001$) has the strongest total effect on *intention to use*, followed by *perceived aesthetics* ($\beta_T = 0.77$, $p < 0.001$) and *perceived persuasiveness* ($\beta_T = 0.42$, $p = 0.06$), which is marginally significant. Specifically, *perceived credibility* ($\beta_T = 0.33$, $p < 0.05$) has a weak total effect on *intention to use*, while *perceived usability* ($\beta_T =$ -0.20, $p = n.s$) has no significant total effect. Moreover, in the individualist model, *perceived persuasiveness* ($\beta_T = 0.66$, $p < 0.001$) is the strongest, followed by *perceived usefulness* ($\beta_T = 0.60$, $p < 0.001$), *perceived aesthetics* ($\beta_T = 0.55$, $p < 0.001$) and *perceived usability* ($\beta_T = 0.21$, $p < 0.001$). *Perceived credibility* ($\beta_T =$ 0.12, $p < 0.01$) turns out to have the weakest total effect on *intention to use* in the individualist model.

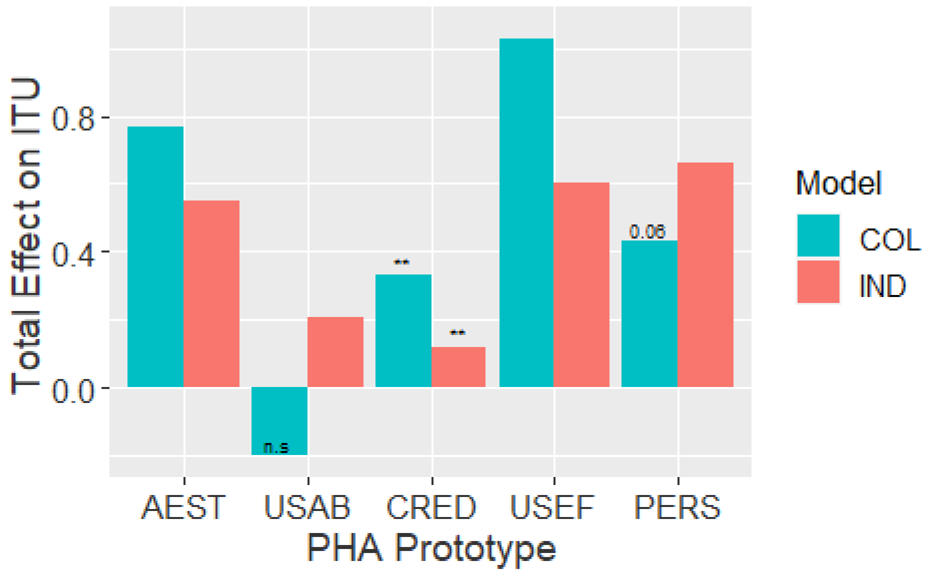

Figure 6.8: Total Effect of perceived UX attributes and perceived persuasiveness on the intention to use (each construct without a label is significant at $p < 0.001$)

6.4.4 Discussion

I have presented a PTAM based on the perceived UX design attributes of a PHA prototype aimed to understand the strongest determinants of the acceptance of a proposed PT intervention. I have also presented results of the mediating effect of the relationship between *perceived usefulness* and *intention to use* by *perceived persuasiveness* and the moderating effect of culture with regard to the relationships between the PTAM constructs. Overall, the GOF values for the culture-specific models are large (over 70%), indicating that the respective models fit their empirical data well. Moreover, the R^2 values are high (over 60%), indicating that, regardless of culture, *perceived usefulness* and/or *perceived persuasiveness* account for a large portion of the variance of *intention to use*. More importantly, over 8 of the 14 hypotheses were validated in each of the models. In this section, in the light of S3a's research questions, I discuss the validation of the hypotheses, the mediation of *perceived persuasiveness*, the cultural differences and the overall (total) effect of the perceived UX design attributes on *intention to use*.

Validation of Hypotheses

Table 6.8 provides a summary of the validated and non-validated hypotheses. Overall, 10 out of the 14 hypotheses are validated in the individualist models, but only 8 of them are validated in the collectivist model. I discuss each of the validated hypotheses and the moderating effect of culture.

Validation of Perceived Aesthetics Related Hypotheses (H1-H4). The summarized findings in Table 6.8 shows that, regardless of culture, all four of the aesthetics-related hypotheses (H1-H4) are supported, only that, in the individualist model, the relationship between *perceived aesthetics* and *perceived persuasiveness*

Table 6.8: Summary of the validated PTAM relationships between constructs based on a PHA prototype. "✓" indicates that the hypothesis is supported, with the bolded one indicating that the relationship in question is greater than (β= 0.20, p < 0.05); "×" indicates the hypothesis is not supported; "-" indicates that the hypothesis is not supported and a negative relationship.

No.	Hypothesis	Relationship	COL	IND
H1	The perceived aesthetics of a PHA will positively influence its perceived credibility.	AEST → CRED	**✓**	**✓**
H2	The perceived aesthetics of a PHA will positively influence its perceived usefulness.	AEST → USEF	**✓**	**✓**
H3	The perceived aesthetics of the PHA will positively influence its perceived usability.	AEST → USAB	**✓**	**✓**
H4	The perceived aesthetics of the PHA will positively influence its perceived persuasiveness.	AEST → PERS	**✓**	✓
H5	The perceived usability of the PHA will positively influence its perceived credibility.	USAB → CRED	×	**✓**
H6	The perceived usability of a PHA will positively influence its perceived usefulness.	USAB → USEF	✓	**✓**
H7	The perceived usability of the PHA will positively influence its perceived persuasiveness.	USAB → PERS	×	×
H8	The perceived usability of a PHA will positively influence users' intention to use it.	USAB → ITU	-	×
H9	The perceived credibility of a PHA will positively influence its perceived usefulness.	CRED → USEF	**✓**	✓
H10	The perceived credibility of a PHA will positively influence its perceived persuasiveness.	CRED → PERS	×	×
H11	The perceived credibility of a PHA will positively influence users' intention to use it.	CRED → ITU	×	×
H12	The perceived usefulness of a PHA will positively influence its perceived persuasiveness.	USEF → PERS	**✓**	**✓**
H13	The perceived usefulness of a PHA will positively influence users' intention to use it.	USEF → ITU	**✓**	✓
H14	The perceived persuasiveness of a PHA will positively influence users' intention to use it.	PERS → ITU	×	**✓**

(H4) is weak ($\beta = 0.16$, $p < 0.05$). That said, the significant direct effect of *perceived aesthetics* on every other construct in the model (apart from *intention to use*) indicates how influential *perceived aesthetics* is in the PTAM. Specifically, the validation of the first four hypotheses show that the higher users perceive the *aesthetics* of a PHA, the higher they will perceive the other UX attributes such as *perceived usability*, *perceived credibility* and *perceived usefulness*. In addition, the higher they will perceive the PHA to be *persuasive*. Particularly, *perceived aesthetics* tends to have a higher direct effect on the proximal constructs (e.g., *perceived usability*) than the distal constructs (e.g., *perceived persuasiveness*), especially in the individualist model. For example, in the individualist model, the corresponding direct effects are ($\beta = 0.79$, $p < 0.001$) and ($\beta = 0.16$, $p < 0.05$), respectively. The multigroup analysis shows that the influence of *perceived aesthetics* on *perceived usability* is significantly stronger in the collectivist culture ($\beta = 0.91$, $p < 0.001$) than in the individualist culture ($\beta = 0.79$, $p < 0.001$). This finding is consistent with an earlier finding in a study of tourism websites. In the study [244], the authors found that, regardless of mobile website design (e.g., color scheme, layout), the relationship between *perceived aesthetics* and *perceived usability* is significantly stronger for the collectivist culture than for the individualist culture ($p < 0.05$). In UX design, the relationship between *perceived* *aesthetics* and *perceived usability* is often regarded as a "halo effect," which is a psychological cognitive bias that causes the perception of one attribute of an object to affect the perception of another attribute [245]. The current finding confirms the prior finding in the tourism domain that the aesthetic-usability "halo effect" is stronger in the collectivist culture than in individualist culture [244].

Validation of Perceived Usability Related Hypotheses (H5-H8). Table 6.8 shows that, at least, one or two of the usability-related hypotheses (H5-H8), in which *perceived usability* is an antecedent, are validated in each of the two models. In the individualist model, the hypothesized relationships between *perceived usability*, on one hand, and *perceived credibility* (H5) and *perceived usefulness* (H6), on the other hand, are supported by the data. This suggests that the higher individualist users perceive the usability of a PHA, the higher they tend to perceive its credibility and usefulness. For the collectivist culture, the relationship between *perceived usability* and *perceived credibility* is not significant ($\beta = 0.31$, $p = n.s$), while that between *perceived usability* and *perceived usefulness* is relatively weak ($\beta = 0.16$, $p < 0.05$). However, the multigroup analysis showed no significant difference between both cultures with respect to both relationships. Regarding the relationship between *perceived usability* and *perceived persuasiveness*, H7 is not validated in either of the culture-specific models. Moreover, regarding H8, the relationship between *perceived usability* and *intention to use* (β = -0.50, $p < 0.001$) in the collectivist model is negative, which does not support our hypothesis. It is noteworthy that the negative path coefficient between both constructs is as a result of an inconsistent mediation by *perceived usefulness* and/or *perceived persuasiveness*, which tend to serve as suppressors [243][72]. For example, when *perceived usefulness* is excluded from the model, the direct effect of *perceived usability* on *intention to use* reduces to (β = -0.17, $p = n.s$). Furthermore, when *perceived usefulness* and *perceived persuasiveness* are both excluded from the model, the direct effect of *perceived usability* on *intention to use* changes direction and increases in magnitude ($\beta = 0.54$, $p < 0.001$). These changes in the sign and strength of the relationship between *perceived usability* and *intention to use* confirm that *perceived usefulness* and *perceived persuasiveness* are acting as suppressors.

Validation of Perceived Credibility Related Hypotheses (H9-H11). Among the usefulness-related hypotheses (H9-H11), in which *perceived usefulness* is an antecedent, only H9 is validated in each of the three models (see Table 6.8). The validation of H9 means that, regardless of culture, the higher a user perceives the credibility of a PHA, the higher the user will perceive it to be useful. Though the relationship between *perceived credibility* and *perceived usefulness* is higher in the collectivist culture ($\beta = 0.32$, $p < 0.001$) than in the individualist culture ($\beta = 0.19$, $p < 0.01$), the result of the multigroup analysis shows that there is no significant difference ($p = n.s$) between both path coefficients. Moreover, our path analysis shows that, regardless of culture, the hypothesized relationships between *perceived credibility*, on one hand, and *perceived persuasiveness* (H10) and *intention to use* (H11), on the other hand, are not validated.

Validation of Perceived Usefulness Related Hypotheses (H12 and H13). As shown in Table 6.8, the two usefulness-related hypotheses (H12 and H13), in which *perceived usefulness* is an antecedent, are validated in each of the models. The validation of H12 means that, regardless of culture, the higher a user perceives a PHA to be useful, the higher the user will find it persuasive. Finding the application persuasive, in the context of our study, means, among other things, the application under evaluation makes the target users want to reconsider their physical activity habits. Though the path coefficient for the relationship between *perceived usefulness* and *perceived persuasiveness* is higher in the individualist model ($\beta = 0.69$, $p < 0.001$) than in the collectivist model ($\beta = 0.33$, $p < 0.01$), the result of the multigroup analysis shows that there is no significant difference between both path coefficients. Moreover, the validation of H13 means that, regardless of culture, the higher a user perceives a PHA to be useful, the higher the user's *intention to use* the application becomes. The result of the multigroup analysis shows that the influence of *perceived usefulness* on the *intention to use* the application is significantly stronger ($p < 0.01$) for the collectivist culture ($\beta = 0.90$, $p < 0.001$) than for the individualist culture ($\beta = 0.14$, $p < 0.05$). Moreover, the effect size of *perceived usefulness* on *intention to use* is large for the collectivist culture, but small for the individualist culture (see Table 6.4). This means that the collectivist group is more likely to adopt a PHA based on its *perceived usefulness* than the individualist group. One plausible explanation for the relatively weak relationship between *perceived usefulness* and *intention to use*, for the individualist culture, is that this direct relationship is partially mediated by *perceived persuasiveness* ($VAF = 0.43$). However, this is not the case for the collectivist culture. This finding suggests that members of the collectivist culture are more likely to adopt a PHA based on its *perceived usefulness* than members of the individualist culture. Prior research [58][109] has shown that users' *intention to use* has the potential to influence the actual use of a PHA.

Validation of perceived persuasiveness Related Hypotheses (H14). The fourteenth hypothesis (H14) is on the relationship between *perceived persuasiveness* and *intention to use*. As shown in Table 6.8, H14 is validated in the individualist model ($\beta = 0.66$, $p < 0.001$), with the size of the effect of *perceived persuasiveness* on *intention to use* being large (see Table 6.4). On the other hand, in the collectivist model, the corresponding relationship is not significant ($\beta = 0.42$, $p = 0.06$). This, coupled with the effect-size value being negative, indicates that *perceived persuasiveness* can be excluded from the collectivist model outright. However, the large size of the effect of *perceived persuasiveness* on *intention to use* in the individualist PTAM suggests that the more individualist users find a health application persuasive the more likely they are to adopt it. Unfortunately, though the path coefficient for the relationship between *perceived persuasiveness* and *intention to use* is relatively high ($\beta = 0.42$, p = 0.06), the significance test showed that it is not significant at $p < 0.05$. Thus, given that there is a marginal significance of the relationship in question, further studies, especially with a larger sample size, need to be conducted in the future to examine this relationship among the collectivist group. However, for the individualist group, the relationship between *perceived persuasiveness* and *intention to use* ($\beta = 0.66$, $p < 0.001$) is significant. This finding is consistent with existing findings in the literature among other individualist populations [58][110]. For example, Drozd et al. [110] investigated the factors that influence the use of a Norwegian persuasive health system. They found that the relationship between both constructs is strongly significant. The current study replicates this finding among Canadian/American individualist populations in the context of a fitness application.

6.4.5 Discussion of Findings in the Light of Research Questions

In this section, I briefly discuss the main findings in the light of the investigation's four subquestions (RQ3a-i to RQ3a-iv) presented earlier on.

Most Important UX Design Determinants. The first research question states, "*Which of the four commonly known UX design attributes is/are the strongest determinants of the intention to use a PHA?*" As an answer to this research question, I present the result of the total-effect analysis. Table 6.9 shows all of the total effects of the four UX design attributes as well as *perceived persuasiveness* on the *intention to use* a PHA in decreasing order of strength. In the collectivist model, *perceived usefulness* has the strongest overall effect on *intention to use*, followed by *perceived aesthetics*, *perceived persuasiveness* and *perceived credibility*. However, *perceived usability*, has a non-significant total effect on *intention to use*. On the other hand, in the individualist model, *perceived persuasiveness* has the strongest overall effect on *intention to use*, followed by *perceived persuasiveness*, *perceived aesthetics* and *perceived usability*. *Perceived credibility* only has a weak total effect on *intention to use*. Thus, without considering *perceived persuasiveness* (which is a consequence of the perceived UX design attributes), *perceived usefulness*, followed by *perceived aesthetics*, is the strongest and thus most important determinant of users' *intention to use* a PHA, regardless of culture.

It is noteworthy that, although *usability* is instrumental to users' satisfaction, in the PTAM, its total effect on *intention to use* is non-significant in the collectivist model and minimally significant in the individualist model. One possible explanation for its less importance than *perceived aesthetics* and *perceived usefulness* is that the study participants did not actually use the PHA. As such, they could not experience its effectiveness and efficiency, which determine *actual usability* [246]. Moreover, *perceived credibility*, which relates to *trustworthiness* and *professionalism* [21] turned out to be non-significant in the PTAM. One plausible reason is that, in the context of the Prominence-Interpretation Theory [247], *perceived credibility* might have been overshadowed by the *perceived aesthetics* of the PHA, which is more prominent in the evaluation process.

Table 6.9: Culture-specific profile based on the UX design determinants of the intention to use a PHA. The underlined construct indicates a significant total effect on intention to use, with solid and dashed lines representing strong ($\beta \geq 0.2$, $p < 0.05$) and weak effects, respectively. The superscripted construct[1] indicates its total effect on intention to use is marginal ($p = 0.06$).

Model	**Order of Strength of Determinants of Intention to Use**
Collectivist	<u>Usefulness</u>, <u>Aesthetics</u>, <u>Persuasiveness[1]</u>, <u>Credibility</u>, Usability
Individualist	<u>Persuasiveness</u>, <u>Usefulness</u>, <u>Aesthetics</u>, <u>Usability</u>, <u>Credibility</u>

In sum, the culture-specific determinants profiles (Table 6.9) suggest that, at the level of perception, pragmatic attributes (such as *perceived usefulness*) and hedonic attributes (such as *perceived aesthetics*) are the most important drivers of users' *intention to use* a PHA. Pragmatic attributes are utilitarian qualities that encompass the practical benefits users derive from using a health application, while hedonic attributes are affective qualities that appeal to the users' emotion visually [248]. In the HCI field, there has been a debate on which of these types of attribute designers should focus on. For example, Chitturi and Chitturi [249] asked the question, "*Should a design manager invest more in improving aesthetics (hedonic benefit) or function (utilitarian benefit)?*" (p. 11). The answer to this question, in the context of the current findings in the PTAM, is that they should design their PHAs to reflect both beauty (*aesthetics*) and utility (*usefulness*). The current findings reveal that both attributes are important to users from both types of cultures. As such, designers should strike a balance between both attributes in their design of PHAs. However, for the collectivist culture, based on the total-effect results (see Table 6.8), a stronger focus should be on *perceived usefulness* than *perceived aesthetics*. *Aesthetics* can be enacted through the appropriate choice of colors/fonts, layout of content, use of images, etc. On the other hand, *usefulness* can be enacted by equipping the health app with the supportive and/or persuasive features users care about. For example, research [62] shows that Goal-Setting/Self-Monitoring is an essential feature of a PHA users care about. In particular, in S2a, I showed that Goal-Setting/Self-Monitoring is one of the most persuasive features to which users from both cultures are receptive. So, highlighting a feature such as Goal-Setting/Self-Monitoring in the advertisement of the app (e.g., on Google Play Store) will amount to showcasing one of its utilities: *helping the users to set goals and track their activities over time*. An essential persuasive feature such as Goal-Setting/Self-Monitoring can help inform users' ultimate decision to use a PHA, as I show later in the PTUM (Section 6.6).

Importance of Perceived Persuasiveness in the PTAM. The second research question states, "*Does the inclusion of perceived persuasiveness in the PTAM improve the model?*" The answer to this research question is moderated by culture. For the individualist culture, the answer is "yes." Upon including *perceived persuasiveness* in the individualist model, the adjusted R^2 value increases substantially by 14% (see Table 6.5), indicating a better model than the individualist model without *perceived persuasiveness*. However, for the collectivist culture, the answer is "no." Upon including *perceived persuasiveness* in the collectivist model, the adjusted R^2 value decreases by 2%, indicating a worse model than the collectivist model without *perceived persuasiveness*. *Perceived persuasiveness* in the PTAM can be compared to *attitude* in the traditional TAM. There have been recommendations in the literature to have *attitude* excluded from the TAM due to its "unimportance" to realize a parsimonious model. This makes *perceived usefulness* the most proximal, unmediated, determinant of *intention to use* [108]. However, some researchers (e.g., [58]) have found that *attitude* is important in the TAM, indicating that it be kept. Specifically, with regard to *perceived persuasiveness* (a proxy for *attitude* in the PTAM [110]), I found that the question of including or excluding it from the PTAM depends on culture. The culture-specific PTAM showed that *perceived persuasiveness* is important in the Canadian/American individualist model but not in the Nigerian collectivist model.

Perceived Persuasiveness as a Mediator in the PTAM. The third research question states, "*Is the effect of perceived usefulness on intention to use mediated by perceived persuasiveness?*" The answer to this research question, again, is moderated by culture, just like the answer to the second research question. In the individualist model, the results of the mediation analysis (Table 6.6) showed that the VAF for the indirect path (*perceived usefulness* $\rightarrow$ *perceived persuasiveness* $\rightarrow$ *intention to use*) is 0.43, which indicates partial mediation. However, in the collectivist model, apart from the relationship (*perceived persuasiveness* $\rightarrow$ *intention to use*) not being significant, the VAF is 0.13 (less than 0.20), indicating no mediation [72]. Hence, in the Canadian/American individualist PTAM, *perceived persuasiveness* partially mediates the direct effect of *perceived usefulness* on *intention to use.* However, in the Nigerian collectivist PTAM, *perceived persuasiveness* does not mediate the direct effect of *perceived usefulness* on *intention to use.*

Culture Differences in the Relationships between Constructs in the PTAM. The fourth research question states, "*Are the interrelationships among the UX design constructs in the PTAM moderated by culture?*" The answer to this research question is that some of the relationships are moderated by culture. For example, I found that the relationship between *perceived aesthetics* and *perceived usability* is stronger for the collectivist group than for the individualist group. This suggests that the collectivist culture is more affected by the aesthetic-usability "halo effect," which is a cognitive bias that causes the perception of one attribute of an object to affect the perception of another attribute [245]. This finding on the aesthetic-usability relationship replicates prior findings in mobile website design [244]. Secondly, I found that the relationship between *perceived usability* and *intention to use* is stronger for the collectivist group than for the individualist group. However, this relationship, which is negative for the collectivist group, is as a result of an inconsistent mediation [243] by *perceived usefulness* and *perceived persuasiveness* of the direct effect of *perceived usability* on *intention to use.* Therefore, further research needs to be done to investigate the said relationship. Thirdly, I found that the relationship between *perceived usefulness* and *intention to use* is stronger for the collectivist group than for the individualist group. This finding can be attributed to the finding that *perceived persuasiveness* partially mediates the effect of *perceived usefulness* on *intention to use* for the individualist group, but does not for the collectivist group. Hence, the direct effect of *perceived usefulness* on the *intention to use* a PHA is stronger for the collectivist group than for the individualist group. Moreover, the overall effect of *perceived usefulness* on *intention to use* is stronger for the collectivist group than for the individualist group, with the strength of the total effect for the former doubling that for the latter. Similarly, regarding the overall effect of the perceived UX design attributes on *intention to use* (see Figure 6.8), *perceived credibility* seems to be stronger in the collectivist model, while *perceived usability* in the individualist model. However, these findings need further investigation in future work to confirm them.

6.4.6 Summary of Main Findings

In conclusion, for easy reference, I summarize the main findings of the investigation (S3a) as follows:

1. Regardless of culture, *perceived usefulness*, followed by *perceived aesthetics* is the strongest and most important UX design determinant of the *intention to use* a PHA.

2. The effect of *perceived usefulness* on the *intention to use* a PHA is stronger in the collectivist culture than in the individualist culture.

3. The inclusion of *perceived persuasiveness* in the PTAM improves the individualist model, but does not the collectivist model.

4. *Perceived persuasiveness* partially mediates the effect of *perceived usefulness* on the *intention to use* a PHA in the individualist model, but does not in the collectivist model.

5. The effect of *perceived aesthetics* on the *perceived usability* of a PHA is stronger in the collectivist culture than in the individualist culture.

6.5 S3b: Investigation of the UX Design Determinants of the Adoption of a PHA among the Target Audience and the Moderating Effect of Culture: a Qualitative Approach

Research [223] shows that the first impression of a HCI system affects the target users' acceptance, usage or abandonment of the system . In the web domain, Lindgaard et al. [216] found that it takes users as little as 50 milliseconds to make the first impression. In the health domain, little qualitative research has been done in the context of PHAs to understand what UX design attributes are most important to users and how they make their judgment regarding accepting a persuasive system. So far, most qualitative research has been focused on websites and *perceived credibility*, in particular (e.g., [162], [250]). Moreover, most qualitative PT studies in the health domain have been focused on persuasive features such as Self-Monitoring [62], Competition, Cooperation, Social Comparison and Social Learning [33][167]. However, research [251] shows that, for persuasive systems to be effective, aside from equipping them with persuasive features, they have to be designed to foster good perceived user experience, which borders on *aesthetics*, *usability*, *usefulness*, *credibility*, etc. [252]. Given the increasing interest in PHAs for supporting users and motivating behavior change (e.g., fitness app, due to the rising global physical inactivity), there is a need to understand the UX design attributes (aside from key persuasive features) users care about the most from a qualitative standpoint. This will help designers to design evidence-based PHAs that foster good user experience.

Thus, this investigation (S3b) aims to uncover the most important UX design attributes the target users care about to confirm the theoretical findings in the PTAM (S3a) using a qualitative approach. Moreover, it aims to uncover evidence for the mediating effect of *perceived persuasiveness* and the moderating effect of culture in the PTAM using the same approach.

6.5.1 Research Questions

In the PTAM, presented in S3a, I found—using path modeling—that *perceived aesthetics* and *perceived usefulness* are the strongest UX design determinants of the *intention to use* a PHA. Moreover, I found that *perceived persuasiveness* mediates the effect of *perceived usefulness* on *intention to use* in the individualist model. To confirm and support these findings with qualitative evidence, this investigation sets out to answer the subquestion (RQ3b), "*What are the prominent UX design attributes of a PHA that grab users' attention and how are they moderated by culture?*" The subquestion is broken down as follows:

RQ3b-i. What UX design attributes make users want to use a PHA?

RQ3b-ii. Are the UX design attributes moderated by culture?

RQ3b-iii. Is there qualitative evidence in the target users' comments about the UI of the PHA that indicates that their *intention to use* it is mediated by *perceived persuasiveness*?

RQ3b-iv. Do the qualitative findings in S3b provide empirical support for the quantitative findings in S3a?

6.5.2 Data Analysis

To provide answers to the four subquestions, I conducted a thematic analysis on the study participants' responses to the open question, "*Please comment on your first impression about the app.*" This question is with regard to the PHA prototype shown in Figure 6.2.

Analytic Framework for Thematic Analysis

To ground the thematic analysis [173] of the comments provided by participants on the PHA prototype in the literature, I used Peter Morville's UX Honeycomb, which I called the "Look-Feel-and-Think UX Design Framework" [252] for evaluating HCI artifacts. The framework states that an information system is considered valuable if it is desirable (aesthetic), usable (easy to use), credible, useful, findable and accessible. All of these design constructs, in the context of evaluating a HCI system by inspection are based on the system's look and feel, user's feeling and thought about it. In other words, potential users think a HCI system is valuable based on their subjective value judgment of the look and feel of the system, which border on the perception of *aesthetics*, *usability*, *credibility*, *usefulness*, etc.

In my thematic analysis of the comments made by the participants about the PHA prototype, I came across several "good" value judgments, which made me to add "*perceived goodness*" to the Look-Feel-and-Think UX Design Framework. However, I found no comments relating to accessibility. As such, this UX design attribute in the original framework is not considered in my adapted analytical framework. Secondly, I considered comments relating to findability (e.g., of information) as usability-related [246]. Thus, in my extended Look-Feel-and-Think UX Design Framework [252], I considered *aesthetics*, *usability*, *credibility*, *usefulness* and *goodness*. Recall, in the PTAM, I found that *perceived persuasiveness* (a proxy for users' *attitude* towards a system) mediates the influence of *perceived usefulness* and *intention to use* among the individualist participants. As such, I added *perceived persuasiveness* (a "Think-based" construct) to the Look-Feel-and-Think UX Design Framework as well to uncover supporting evidence for the said mediation.

For this reason, in the context of PT, I regard a valuable system as a persuasive system, which users are likely to adopt because they consider it *aesthetic*, *usable*, *credible*, *good* and *useful*. Based on this definition of a persuasive system, from the perspective of the user, in my thematic analysis of participants' comments about the PHA prototype, I coded for *design look*, *perceived aesthetics*, *perceived usability*, *perceived credibility*, *perceived usefulness*, *perceived goodness*, *perceived persuasiveness* and *adoption* (i.e., *intention to use* the application). I briefly provide an overview of these UX design attributes and constructs.

Design Look. *Design look* refers to how a system appears to the user. In website design, research shows it is the antecedent of most UX design attributes such as *perceived credibility*. In a web credibility study among over 2500 participants, Fogg [253] found that *design look* dominated the comments provided by the study participants about the credibility of the investigated websites. Specifically, 46.1% of the comments were based on *design look*. Thus, in my thematic analysis, I coded comments that contained the word "look" as "*design look*." In general, the *design look* of a system is embodied by certain design features such as its content, functionality, the presentational style of the content and the interactional style. These design features, which are composed of design elements such as text, image, font, color, layout, etc., are "*chosen and combined by a designer to convey a particular, intended product character*" (*p.* 32) [236]. Thus, the *design look* can be likened to what Hassenzahl [236] referred to as product character, which is composed of two key types of UX design attributes: *hedonic* and *pragmatic*. Hedonic attributes, such as *perceived aesthetics*, appeal to users and foster a feeling of pleasure. In contrast, pragmatic attributes, such as *perceived usability* and *perceived usefulness*, have the potential to provide satisfaction when users actually interact with the product. Hassenzahl [236] explained that when users evaluate a HCI system, they construct an apparent product character based on their perception, their personal standards, knowledge, experience and expectations. According to the author, this product character construction leads to certain consequences such as "good" or "bad" value judgment about the system. Specifically, he stated that the product character, which summarizes its attributes, functions to "*reduce cognitive complexity and to trigger particular strategies for handling the product*" (p. 32).

Perceived Aesthetics. *Perceived aesthetics* refers to the visual appeal of a system to the user. It is a hedonic attribute, which fosters pleasure and influences other attributes such as *perceived usability* and *perceived credibility* [244]. In Fogg's [253] study, *perceived aesthetics* is coded as an aspect of *design look*. In the study, 46.1% of the participants' comments were about *design look*. In my thematic analysis, I coded comments that had to do with attractiveness, nicety, cleanness, prettiness, creativity, simplicity, minimalism, beauty, ugliness, layout, etc., as "*perceived aesthetics*."

Perceived Usability. *Perceived usability* refers to the degree to which a user believes that using a system will be free of effort [106]. It is a pragmatic attribute, which is strongly influenced by *perceived aesthetics* [244]. In Fogg's [253] study, information design/structure, related to *perceived usability*, turned out to be the second most-commented-about attribute (28.5%). In my thematic analysis, I coded comments that had to do with ease of use, organization of information, navigation, interaction, readability, understandability, clarity, etc., as "*perceived usability*."

Perceived Credibility. *Perceived credibility* refers to the believability of a HCI system, which is judged based on the perceived trustworthiness of the system and perceived expertise of the designers. Research [244] shows that it is influenced by *perceived aesthetics* and *perceived usability.* In Fogg's [253] study, name recognition and reputation, related to *perceived credibility*, turned out to be the seventh most-commented-about attribute (14.1%). In my thematic analysis, I coded comments that contained the words "professional," "trustworthy," "credible," "well-designed," as "*perceived credibility.*"

Perceived Usefulness. *Perceived usefulness* is the degree to which users believe that a system can help them achieve their goals [106]. It is a utilitarian attribute, influenced by *perceived aesthetics*, *perceived usability* and *perceived credibility.* In Fogg's [253] study, information usefulness, turned out to be the fifth most-commented-about attribute (14.8%). In my thematic analysis, I coded comments that contained words such as "helpful," "useful," "functional," "promising," necessary," "good information," as "*perceived usefulness.*"

Perceived Goodness. *Perceived goodness* is the value judgment (positive) users make about a system. According to Domingo [254], a good system design entails being aesthetic, usable, useful, credible, innovative, long-lasting, honest, etc. This means, for a system (design) to be regarded as "good," it has to fare well in these descriptive qualities, most of which are found in Peter Morville's UX Design Framework [252]. In the evaluation of an information system that users have not actually used (i.e., interacted with), users often use their subjective value judgment to determine whether the system is good or not. According to Lin and Chan [255], when users are "*unfamiliar with new services or products, less experienced, or lack of knowledge, subjective value judgment becomes the basis of users' decision making*" (p. 315). Moreover, according to Jones [256], a "*[g]ood design is design that changes behavior for the better.*" In the thematic analysis of participants' comments, I coded comments that described the fitness app design as "good" as "*perceived goodness.*"

Perceived Persuasiveness. *Perceived persuasiveness* is the evaluative effect a system has on users towards changing their behavior. It is often influenced by *perceived aesthetics*, *perceived usability*, *perceived usefulness* and *perceived credibility* [109][239][257]. Hence, a system that is perceived to be persuasive is one that is able to change the target users' attitude or behavior. For example, in website design, Fogg [253] described a persuasive system as one that makes users: (1) think positively about the operator of the website; (2) feel comfortable using the website; and (3) adopt the website's viewpoint. In the thematic analysis, to code a comment as "*perceived persuasiveness*," I assumed the expression of like for a system's design means the system is perceived persuasive. This assumption is based on the notion that "*the more someone likes an object, the more likely they are to engage in behaviors directed toward that object*" (p. 2) [258]. Thus, I coded comments containing "like," e.g., "*I like the app*," as "*perceived persuasiveness.*" Moreover, I coded comments containing "motivating," "impressive," and "appealing to me" as "*perceived persuasiveness*" as well. One of the main reasons for coding them as "*perceived persuasiveness*" is that one of the items in Lehto et al.'s [109] *perceived persuasiveness* scale as extended by Orji [206], which I adapted (see Table 6.1), is, "*This feature of the app would be convincing.*" "Convincing" can be likened to "motivating," "impressive," and "appealing to me," all of which indicate the potential to change users' attitude in the intended direction.

The Evaluative Process Model for Persuasive System Adoption

I based the thematic analysis of participants' comments about the PHA prototype on the proposed process model shown in Figure 6.9. Also called the perception-to-adoption model, the process model comprises four phases (System, Evaluation, Attitude and Intention), which mirrors the PTAM (Figure 6.5). It is adapted from Tractinsky's [259] general framework for studying the visual aesthetics of HCI systems. Based on the prior literature on emotional design [260], I argue that, in the evaluation of a PHA, users would engage with it at different levels of affect and cognition, ranging from the system domain (where users assess descriptive qualities and make judgments) to the user domain (where users make decisions to adopt the system).

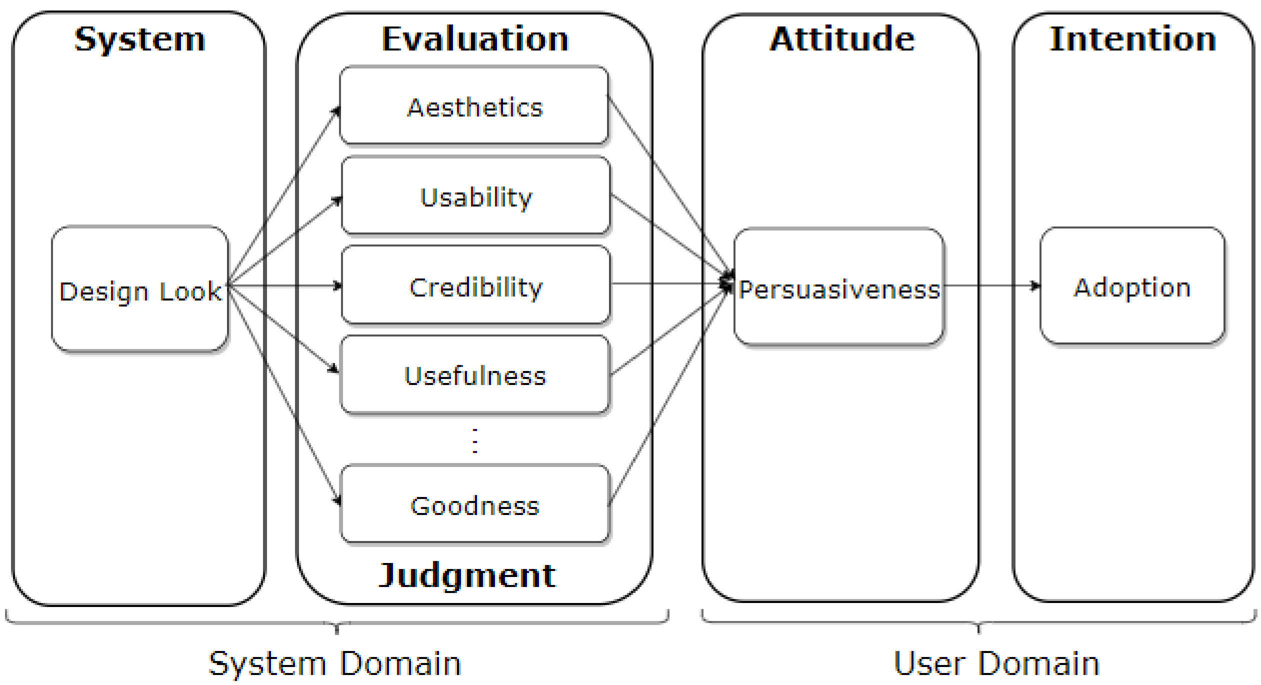

Figure 6.9: The Evaluative Process Model for Persuasive System Adoption

In the Evaluation/Judgment phase, I anticipate that different users would assess the persuasive system at different levels based on how it's *design look* appeals to and impacts them. For example, evaluation concerned with constructs at the upper part of the Evaluation/Judgment phase can be regarded as visceral (feeling-based, e.g., *perceived aesthetics*) and thus are most likely to occur. Moreover, evaluation focused on constructs at the lower part can be regarded as cognitive (utility-based, e.g., *perceived usefulness*), which requires thought and careful examination, and thus less likely to occur. In the context of the Prominence-Interpretation Theory [247], the upper constructs are attributes that are more likely to be noticed (Prominence), while the lower constructs are judgments the users make about the system (Interpretation), which are less likely to occur. As I showed in the PTAM, the constructs in the Evaluation/Judgment phase can influence the *perceived persuasiveness* of the system and users' *intention to use* it. Overall, the evaluation process can be categorized into two levels: *visceral* (directed at the system) and *reflective* (directed at the user).

Visceral Level of System Evaluation. The visceral level is defined as the most proximal and immediate level in the evaluation of a system, which involves potential users subconsciously reacting to the visual and other sensory aspects of the system prior to actually interacting or using it [261]. Specifically, the visceral-level evaluation helps the potential users make rapid decisions about what is good or otherwise about the system [262]. It can be likened to Hassenzahl's [236] construction of a product's character by potential users when they first come in contact with it. According to Hassenzahl [236], the construction of a product's character achieves two goals: (1) serves to "*reduce cognitive complexity and to trigger particular strategies for handling the product*" (p. 32), and (2) leads to certain consequences such as "good" or "bad" value judgment about the product. Although, in the process model, *perceived persuasiveness* mediates the adoption of a persuasive system (e.g., having the *intention to use* the system), a user could actually decide to use it because of some of its perceived UX design attributes (e.g., *perceived aesthetics* in the Evaluation/Judgment phase) without having to go through the Attitude phase, which is influenced by *perceived persuasiveness* [263][264][265]. In the context of Elaboration Likelihood Model [266], this can be regarded as taking the peripheral path to adoption rather than the central path (which involves *perceived persuasiveness*). In that case, the user may not use the adopted system for long compared with a user who was persuaded to use the system through the central path, which involves a change of attitude brought about by elaboration and reflection. According to the Elaboration Likelihood Model [266], the central path to persuasion is based on a more thoughtful evaluation of the system (which involves evaluating *perceived usefulness* and getting influenced (*perceived persuasiveness*)) than the peripheral path that is based on simple cues (such as *perceived aesthetics*).

Reflective Level of System Evaluation. *Perceived persuasiveness* in the process model can be compared to the reflective level of emotional design, which entails the conscious processing and active evaluation of the affordances of a system, including how it relates to the users on a personal level, its place in their social environment, and how it reflects upon them to own and use the system. Reflective evaluation is regarded as the highest level of Norman et al.'s [267] three-level model of emotional design. It uses information from the other two levels (visceral and behavioral) in concert with the user's knowledge and experiences, and thus is least likely to occur in the evaluation process [260]. This notion of reflection is evident in the operationalization of *perceived persuasiveness* in S3a. For example, one of the questions in the *perceived persuasiveness* scale (see Table 6.1) is that "*the app will be personally relevant to me.*" Another question is, "*the app will make me reconsider my physical activity.*" These questions tend to prompt the target users to reflect on their current, past and future physical activities as I show later in the participants' comments. I anticipated that, given that it requires more cognition and personal experience at the reflective level, the comments made by the participants about the PHA prototype are more likely to be skewed to the left of the process model and to the top part of the Evaluation/Judgment phase, in particular. In other words, the participants' comments are more likely to be made at the visceral level than at the reflective level. This means that their comments on the PHA prototype will be more about *design look*, *perceived aesthetics* and *perceived usability* than about *perceived usefulness*, *perceived persuasiveness* and *intention to use.*

6.5.3 Results

In this section, I present a summary of the thematic analysis of participants' comments about the fitness application prototype. Secondly, I present the empirical evidence supporting the proposed process model for the evaluation and adoption of a persuasive system shown in Figure 6.9, taking each of the UX design attributes/constructs in the model at a time.

Perceived UX Design Attributes and Related Constructs in the Evaluation of a Persuasive System

Table 6.10 shows the UX design-related constructs the study participants were concerned about during the evaluation of the fitness application prototype based on their first impression. Overall, most of the participants' comments were focused on constructs to the left of the process model. For example, the participants' comments were mostly related to *perceived aesthetics* (41.8%), followed by *design look* (29.2%), *perceived usability* (19.2%), *perceived usefulness* (15.6%), *perceived goodness* (12.9%), *perceived persuasiveness* (9.4%), *perceived credibility* (5.0%) and *adoption* (4.7%). As I anticipated, the participants' comments, regardless of culture, were least focused on constructs to the right of the process model, e.g., *perceived persuasiveness* and *adoption* (i.e., *intention to use* the PHA). The only exception is *perceived credibility*, which percentage of participants' comments tends to be lower than that of *perceived persuasiveness*.

Table 6.10: Percentage of participants in collectivist and individualist cultures that commented on each perceived UX design attribute or related construct in the evaluation of the PHA

No.	Construct	Overall	COL	IND	%DIFF
1	Perceived Aesthetics	41.8	32.8	42.3	-12.2
2	Design Look	29.2	11.9	35.4	-23.5
3	Perceived Usability	19.2	9.0	22.8	-13.8
4	Perceived Usefulness	15.6	17.9	14.8	3.1
5	Other Attiributes/Constructs	14.4	17.9	15.9	4.7
6	Perceived Goodness	12.9	16.4	11.6	4.8
7	Perceived Persuasiveness	9.4	7.5	10.1	-2.6
8	Perceived Credibility	5.0	1.5	6.3	-4.8
9	Adoption (Intention to Use)	4.7	4.5	4.8	-0.3

Empirical Evidence Supporting the Evaluative Process Model for Persuasive System Adoption

In this section, I focus on the empirical evidence (i.e., participants' comments on each perceived UX design construct) that supports the evaluative process model for persuasive system shown in Figure 6.9.

Design Look. Table 6.11 shows a cross-section of the participants' comments on the fitness application prototype's *design look*, with the individualist participants (35%) having a higher percentage of comments than the collectivist participants (12%). The comments on *design look* are on a wide range of perceived attributes such as *aesthetics*, *usability*, *credibility*, *usefulness*, etc., as shown in the evaluative process model for persuasive system adoption. For example, regarding *perceived aesthetics*, P222 (a collectivist participant) commented on the *design look* thus, "***It looked pleasing to my eyes.***" Similarly, P125 (an individualist participant) commented on the *design look* thus, "***It looks clean simple and appealing.***" Regarding usability, P215 (a collectivist participant) commented on the *design look* in this way, "*It doesn't* ***look complicated. looks friendly.***" Similarly, P17 (an individualist participant) commented, "*It* ***looks*** *nice and* ***simple to use.***" Regarding *perceived credibility*, P249 (a collectivist participant) commented that the design "***[l]ooked too professional.***" Similarly, P111 (an individualist participant) commented on the *design look* thus, "*It* ***looks professional*** *and summary info is typical of apps I have seen.*" Regarding *perceived usefulness*, P64 (an individualist participant) commented that the design "***looks useful and i like the UI.***"

Perceived Aesthetics. Table 6.12 shows a cross-section of the participants' comments on the *perceived aesthetics* of the fitness application prototype. The individualist participants (42%) had a higher percentage of comments on the *perceived aesthetics* of the application prototype than the collectivist participants (33%). Qualifying words such as "***clean***," "***cool***," "***pretty***," "***nice***," "***appealing***," "***neat***," "***plain***," "***simple***," "***colorful***," "***minimalistic***," "***creative***," "***innovative***," "***modern***," "***pleasing***," "***amazing***," "***ugly***," "***visual***," "***sleek***," "***layout***," "***well-organized***," etc., were used by both groups to convey the perception of aesthetics. The collectivist participants predominantly used words such as "***cool***" and "***nice***," to describe the aesthetics of the design, e.g., P197, P224, P241, P252, etc. However, participants such as P208 and P222 remarked that the app *design look*ed "***visual***" and "***pleasing to my eyes***," respectively. On the other hand, the individualist participants used more descriptive words such as "***clean***," "***simple***," "***pleasing***," "***appealing***," etc. For example, P10 remarked that the design is "***clean and appealing to the eye.***" Similarly, P153 remarked that the design "***is aesthetically pleasing.***"

Perceived Usability. Table 6.13 shows a cross-section of the participants' comments on the *perceived usability* of the fitness application prototype. The individualist participants (23%) had a higher percentage of comments on the *perceived usability* of the application prototype than the collectivist participants (9%). Phrases such as "***ease to use***," "***clear***," "***easy to read***," "***easy to understand***," "***intuitive***," "***easy to see***," "***easy on the eye***," "***simple to use***," "***easy to navigate***," "***friendly***," etc., were used to describe *perceived usability* by the participants. For example, among the collectivist participants, P204 said that the design is "***[v]ery easy to use***," while, P245 said the interface is "***friendly.***" We also see similar comments from the individualist participants. For example, P163 commented, "*I like it because* ***it looks clean simple and easy to understand.***" In the same vein, P104 commented about the app thus, "***Easy Home Screen to read and navigate.***"

Table 6.11: Participants' comments related to design look

Sample comments from collectivist and individualist participants on the PHA prototype	COL	IND
Design Look - “***Looks great***” [P193] – COL. - “***Looks cool***” [P197] – COL. - “*It doesn’t* ***look complicated. looks friendly***” [P215] – COL. - “*It* ***looked pleasing to my eyes***” [P222] – COL. - “***Looks nice***” [P224] – COL. - “***looks good***” [P233] – COL. - “***Looked too professional***” [P249] – COL. - “***Look nice***” [P252] – COL. - “***looks professional***” [P3] – IND. - “***Looks helpful***” [P7] – IND. - “***It looks like it is user friendly***” [P8] – IND. - “*It* **looks nice Good design** *and layout Decent idea Not very novel though*” [P12] – IND. - “*It* **looks nice and simple** *to use*” [P17] – IND. - “*I dont have a strong impression either way It* ***looks okay and functional***” [P18] – IND. - “*It* ***looks very generic***” [P19] – IND. - “*It* **looks good** *but I do not see what separates it from other fitness apps*” [P21] – IND. - “*I like the interface the visuals the colors It* ***looks like a very innovative app***” [P26] – IND. - “*It* ***looks intuitive***” [P28] – IND. - “*It* **looks good** *It has good information*” [P30] – IND. - “*It* **looks good** *It reminds me of Duolingo and Fitbit apps*” [P33] – IND. - “**Looks interesting** *but not sure this is anything unique*” [P38] – IND. - “*it* **looks nice and clean** *simple to use*” [P45] – IND. - “*This* ***looks like one of the many fitness apps*** *that you can find on smart phones*” [P48] – IND. - “*My first impression is it* **looks good** *I hope it has a ton of features*” [P53] – IND. - “***looks cleanly designed***” [P63] – IND. - “*it* **looks useful** *and i like the UI*” [P64] – IND. - “*I* **like the look** *of it*” [P66] – IND. - “*1t* ***looks smooth and easy to use***” [P67] – IND. - “***looks user friendly***” [P68] – IND. - “**looks pretty** *and has calorie burn and minutes spent exercising which is important*” [P69] – IND. - “*It* ***looks cool***” [P81] – IND. - “***Looks clean nice professional***” [P82] – IND. - “*It* ***looks kinda ugly***” [P83] – IND. - “*The layout and interface* **looks good** *and easy to understand*” [P103] – IND. - “*I think it* ***looks appealing***” [P107] – IND. - “*It* **looks professional** *and summary info is typical of apps I have seen*” [P111] – IND. - “***Looked stylish and minimalistic***” [P135] – IND. - “**Looks goods** *but not professional it looks something for people who dont exercice*” [P137] – IND. - “*It* **looks streamlined** *and straightforward*” [P138] – IND. - “*It* **looks nice** *would probably motivate me to exercise sometimes*” [P142] – IND. - “*It* **looks nice** *and has a simple interface*” [P156] – IND. - “*It* **looks fine** *as long as it has the basics needed to track your fitness*” [P157] – IND. - “**Looks good** *seems user friendly*” [P160] – IND. - “**Looks clean** *and with clear precise information*” [P162] – IND. - “*I like it because it looks clean simple and easy to understand*” [P163] - IND. - “**looks simple** *and easy to use withj a minimalist aesthetic*” [P164] – IND. - “**looks straight forward** *and to the point*” [P169] – IND. - “*App* **looks interesting** *but also reminds me of Black Mirror*” [P171] – IND. - “**Looks clean** *and easy to use*” [P174] – IND. - “**Looks nice** *but not sure I would use am app*” [P180] – IND. - “*It* ***looks fun***” [P183] – IND. - “*It***looks clean** *and easy to read*” [P184] – IND. - “***looks cool***” [P188] – IND. - “**looks clean** *i like the green*” [P189] – IND.	12%	35%

Table 6.12: Participants' comments related to perceived aesthetics

Sample comments from collectivist and individualist participants on the PHA prototype	COL	IND
Perceived Aesthetics - "***Looks cool***" [P197] – COL. - "***Simple***" [P198] – COL. - "***Nice***" [P199] – COL. - "***Nice***" [P202] – COL. - "***Simple***" [P205] – COL. - "***The App is visual***" [P208] – COL. - "*It looked* ***pleasing to my eyes***" [P222] – COL. - "***Looks nice***" [P224] – COL. - "***Nice***" [P227] – COL. - "***Cool***" [P235] – COL. - "***Cool***" [P240] – COL. - "*It has a* ***nice UI***" [P241] – COL. - "***Nice one***" [P244] – COL. - "***It's creative.***" [P248] – COL. - "***Look nice***" [P252] – COL. - "***Cool***" [P255] – COL. - "***Nice***" [P256] – COL. - "*it is* ***attractive and nice colour scheme***" [P2] – IND. - "***It is clean and appealing to the eye*** *I like the layout it is easy to read and see everything*" [P10] – IND. - "***Plain***" [P15] – IND. - "*I like the* ***sleek design*** *of the app a lot easy on the eyes*" [P16] – IND. - "*It looks* ***nice and simple*** *to use*" [P17] – IND. - "*It looks* ***very generic***" [P19] – IND. - "***Very clean and minimal***" [P22] – IND. - "*It appears to be* ***very simple in nature***" [P24] – IND. - "***It is minimalistic*** *and professional looking which is quite* ***visually appealing*** *to me*" [P25] – IND. - "*I like the interface the visuals the colors It looks like a* ***very innovative app***" [P26] – IND. - "***Pleasing***" [P29] – IND. - "*Looks interesting but not sure this is anything unique*" [P38] – IND. - "***It looks sleek***" [P40] – IND. - "*I like the general****layout and aesthetic*** *and it feels modern and I generally like using it*" [P47] – IND. - "*I think it is* ***very cleanly designed*** *and easy to read*" [P50] – IND. - "*The app has a professional clean design that* ***looks appealing***" [P51] – IND. - "*I think the app is* ***very clean*** *and refreshing*" [P54] – IND. - "*I like the* ***layout***" [P55] – IND. - "***Simple*** *and easy to use*" [P61] – IND. - "*looks* ***cleanly designed***" [P63] – IND. - "*This app looks very well designed and* ***appealing***" [P65] – IND. - "*looks* ***smooth*** *and easy to use*" [P67] – IND. - "***looks pretty*** *and has calorie burn and minutes spent exercising which is important*" [P69] – IND. - "***is nice***" [P71] – IND. - "***Pretty cool and clean***" [P72] – IND. - "***pretty good***" [P73] – IND. - "***nice design*** *clear stats*" [P78] – IND. - "***Clean***" [P79] – IND. - "***nice***" [P80] – IND. - "*It* ***looks cool***" [P81] – IND. - "***Looks clean*** *nice professional*" [P82] – IND. - "*It looks* ***kinda ugly***" [P83] – IND. - "***awesome***" [P92] – IND. - "*I think it looks* ***appealing***" [P107] – IND. - "***The layout if beautiful*** *and the information is well placed*" [P122] – IND. - "*It looks* ***clean simple and appealing***" [P126] – IND. - "*Looked* ***stylish and minimalistic***" [P135] – IND. - "***Very attractive*** *and easy to read*" [P147] – IND. - "*It is* ***aesthetically pleasing***" [P153] – IND. - "*looks simple and easy to use withj a* ***minimalist aesthetic***" [P164] - IND.	33%	42%

Table 6.13: Participants' comments related to perceived usability

Sample comments from collectivist and individualist participants on the PHA prototype	**COL**	**IND**
Perceived Usability - "***Very easy to use***" [P204] – COL. - "*It doesn't look **complicated. looks friendly***" [P215] – COL. - "***clear***" [P231] – COL. - "*The app interface is **quite interactive***" [P234] – COL. - "***Easy to use** and reduction of cost of hiring a trainer*" [P242] – COL. - "***Friendly interface.***" [P245] – COL. - "*It is clean and appealing to the eye I like the layout it is easy to read and see everything*" [P10] – IND. - "*i like that the caloric intake is **easy to see and understand** with the circle visual i like the green and white colors*" [P11] – IND. - "*Modern design that seems **easy to navigate***" [P14] – IND. - "*I like the sleek design of the app **a lot easy on the eyes***" [P16] – IND. - "*It looks nice and **simple to use***" [P17] – IND. - "***I do not understand** what it actually does*" [P20] – IND. - "*It looks **intuitive***" [P28] – IND. - "***easy to read***" [P32] – IND. - "*It looks like **a user friendly app***" [P37] – IND. - "*it looks nice and clean **simple to use***" [P45] – IND. - "*I think it is very cleanly designed and **easy to read***" [P50] – IND. - "*it **looks easy***" [P60] – IND. - "*Simple and **easy to use***" [P61] – IND. - "*1t looks smooth and **easy to use***" [P67] – IND. - "*looks **user friendly***" [P68] – IND. - "*nice design **clear stats***" [P78] – IND. - "*The layout and interface looks good and **easy to understand***" [P103] – IND. - "***Easy Home Screen to read and navigate***" [P104] – IND. - "*seems nice and **streamlined***" [P110] – IND. - "*clean and **user friendly***" [P112] – IND. - "***user friendly***" [P113] – IND. - "*Looks very clean and **easy to understand***" [P115] – IND. - "*Looks **simple to use***" [P117] – IND. - "*The layout if beautiful and **the information is well placed***" [P122] – IND. - "*Clean and **organized maybe a quick add button in the top right***" [P125] – IND. - "*Looks **easy to read***" [P131] – IND. - "seems *well designed and **user friendly***" [P134] – IND. - "*It looks **streamlined and straightforward***" [P138] – IND. - "***simple and easy to understand***" [P141] – IND. - "***The tip of the day is blocking the weekly stat graph information** this is probably the first thing I would want to look at when opening the app*" [P145] – IND. - "*Very attractive and **easy to read***" [P147] – IND. - "*Looks good seems **user friendly***" [P160] – IND. - "*Clean looking and **easy to read the important statistics***" [P161] – IND. - "*Looks clean and with **clear precise information***" P162] – IND. - "*I like it because it looks clean **simple and easy to understand***" [P163] – IND. - "*looks **simple and easy to use** withj a minimalist aesthetic*" [P164] – IND. - "***looks straight forward and to the point***" [P169] – IND. - "*Looks clean and **easy to use***" [P174] – IND. - "*Simple and streamlined*" [P177] – IND. - "*It looks clean and **easy to read***" [P184] – IND.	9%	23%

Perceived Credibility. Table 6.14 shows a cross-section of the participants' comments on the *perceived credibility* of the fitness application prototype. Specifically, 6% of the individualist participants and 2% of the collectivist participants made comments that are related to *perceived credibility*. For the most part, the word "professional," which suggests the perceived expertise of the designer [268], is used as a proxy for describing the *perceived credibility* of the fitness application. For example, P249 (a collectivist participant) commented that the application "***[l]ooked too professional.***" Similarly, P51 (an individualist participant) commented that "***[t]he app has a professional*** *clean design that looks appealing.*" Another term used to describe the perceived expertise of the designer is "***well-designed.***" This is evident in the comments made by P134 ("***seems well designed*** *and user friendly*") and P144 ("***It looks like it was designed well***").

Table 6.14: Participants' comments related to perceived credibility

Sample comments from collectivist and individualist participants on the PHA prototype	COL	IND
Perceived Credibility - "*Looked too* ***professional***" [P249] – COL. - "***looks professional***" [P3] – IND. - "*It is minimalistic and* ***professional looking*** *which is quite visually appealing to me*" [P25] – IND. - "*it* ***looks professional***" [P31] – IND. - "*It looks like it was* ***designed well***" [P44] – IND. - "***looks professional***" [P49] – IND. - "*The app has a* ***professional clean design*** *that looks appealing*" [P51] – IND. - "*This app looks very* ***well designed*** *and appealing*" [P65] – IND. - "*Looks clean nice* ***professional***" [P82] – IND. - "*seems* ***well designed*** *and user friendly*" [P134] – IND. - "*Looks goods but* ***not professional*** *it looks something for people who dont exercice*" [P137] – IND. - "*It* ***looks professional*** *and summary info is typical of apps I have seen*" [P111] – IND.	2%	6%

Perceived Usefulness. Table 6.15 shows most of the participants' comments on the *perceived usefulness* of the fitness application prototype. Although the percentage difference is not large, a higher percentage of the collectivist participants (18%) commented on *perceived usefulness* than the percentage of individualist participants (15%). The comments are either explicitly stated, using the word, "useful," or implicitly stated, referring to the utility of the fitness application. Examples of explicit comments include that by P56, who stated that the fitness application is "***[v]ery useful for people who can not make it to the gym consistently.***" On the other hand, implicit comments that allude to the *perceived usefulness* of the application include: (1) "***I thinks its going to be Goal oriented***," made by P239 (a collectivist participant); and (2) "*This app seems like it would be* ***helpful to keep track of progress***," made by P144 (an individualist participant). Other words used to indicate the *perceived usefulness* of the application are "help," "helpful," etc. For example, P217 commented that the app will "***help to reduce stress and keep you fit.***" Similarly, P186 commented that the app "***could help people exercise more easily.***"

Perceived Goodness. Table 6.16 shows most of the participants' comments on the *perceived goodness* of the fitness application prototype. A higher percentage of the collectivist participants (16%) comments were on *perceived goodness* than the percentage of individualist participants (12%). As I mentioned before, I took the word, "good" in the participants' comments on the whole or any aspect of the application to mean *perceived goodness*. For example, P192 (a collectivist participant) commented the application is "***a very good one***" (whole design). Moreover, P30 (an individualist participant) commented that "***[i]t looks good[.] It has good information***" (whole and information design).

Table 6.15: Participants' comments related to perceived usefulness

Sample comments from collectivist and individualist participants on the PHA prototype	COL	IND
Perceived Usefulness - "***It help to reduce stress and keep you fit***" [P217] – COL. - "*I* ***help continue until you reach the goal of the day.***" [P219] – COL. - "***Helpful***" [P228] – COL. - "***It could be helpful***" [P229] – COL. - "*The app is great,* ***will come in handy***" [P230] – COL. - "*I thinks its going to be* ***Goal oriented***" [P239] – COL. - "*Easy to use and* ***reduction of cost of hiring a trainer***" [P242] – COL. - "*I would love the app to* ***be able to interface with other devices to collect data about my physical activities*** *instead of entering data manually into the app*" [P209] – COL. - "***Looks helpful***" [P7] – IND. - "*I think* ***it would be useful***" [P9] – IND. - "*I dont have a strong impression either way It looks okay and functional*" [P18] – IND. - "*im not keen on putting in calorie information for everything i eat its to much of a hassle* ***I just need pedometer and history tracker everything else is fluff***" [P27] – IND. - "*It looks good* ***It has good information***" [P30] – IND. - "*It looks like it covers everything*" [P35] – IND. - "*I like the idea of the app and it looks like* ***it would be useful*** *It is something I would consider downloading*" [P42] – IND. - "***Unnecessary***" [P43] – IND. - "***Very useful for people who can not make it to the gym consistently***" [P56] – IND. - "***it looks useful*** *and i like the UI*" [P64] – IND. - "***tips of the day*** *impressed me a lot*" [P91] – IND. - "***Replaceable***" [P124] – IND. - "***It looks useful for tracking your activity***" [P127] – IND. - "***Useful***" [P130] – IND. - "*Good app with daily and weekly goals to achieve its challenging*" [P132] – IND. - "***useful***" [P133] – IND. - "***Looks useful***" [P136] – IND. - "*This app seems like it would be* ***helpful to keep track of progress***" [P144] – IND. - "***looks promising***" [P154] – IND. - "***Rather track minutes active instead of calories burned***" [P167] – IND. - "***helpful***" [P173] – IND. - "***The model makes me want to exercise***" [P175] – IND. - "***helpful***" [P176] – IND. - "***I do not need it at all***" [P182] – IND. - "***it could help people exercise more easily***" [P186] – IND. - "***Good for tracking***" [P187] – IND. - "***perhaps useful***" [P1] – IND.	18%	15%

Perceived Persuasiveness. Table 6.17 shows most of the participants' comments on the *perceived persuasiveness* of the fitness application prototype and the culture-specific percentages: collectivist participants (8%) and individualist participants (10%). In the thematic analysis, I found that most of the participants' comments relating to *perceived persuasiveness* expressed liking for the fitness application design (as a whole or for particular aspects). For example, P5 (an individualist participant) commented, "***I like the overall design of the home page***" (whole design) Moreover, P237 (a collectivist participant) commented, "***I like the interface and the daily tip***" (particular aspect of the design). Other words that indicate *perceived persuasiveness* include "impressive," "motivating," etc. For example, P226 commented that the application is "***[m]otivating***," while P212 remarked, "***It's impressive.***"

Table 6.16: Participants' comments related to perceived goodness

Sample comments from collectivist and individualist participants on the PHA prototype	COL	IND
Perceived Goodness - "***its a very good one***" [P192] – COL. - "***Very good***" [P200] – COL. - "***Good***" [P203] – COL. - "***Good***" [P207] – COL. - "***Good***" [P221] – COL. - "***good***" [P246] – COL. - "***Very good***" [P253] – COL. - "***Good.*** *But there are apps like this already*" [P254] – COL. - "*I feel it's a* ***good idea***" [P379] – COL. - "***It looks good It has good information***" [P30] – IND. - "***its good***" [P74] – IND. - "***very good***" [P76] – IND. - "***GOOD***" [P85] – IND. - "***good***" [P86] – IND. - "***good***" [P90] – IND. - "***Very good app to use***" [P93] – IND. - "***good***" [P98] – IND. - "***good***" [P100] – IND. - "***good***" [P168] – IND.	16%	12%

Table 6.17: Participants' comments related to perceived persuasiveness

Sample comments from collectivist and individualist participants on the PHA prototype	COL	IND
Perceived Persuasiveness - "*Not too much detail, but* ***i like it.***" [P206] – COL. - "*It has a lot of features like the weekly goal that will* ***serve as a motivation for me***" [P211] – COL. - "***It's impressive***" [P212] – COL. - "***Gives that exercise feeling at first glance****, when last did I workout...the graphics and colour chosen are all good*" [P224] – COL. - "***Motivating***" [P226] – COL. - "***I like the interface and the daily tip***" [P237] – COL. - "***I like the overall design of the home page***" [P5] – IND. - "*It is clean and appealing to the eye* ***I like the layout*** *it is easy to read and see everything*" [P10] – IND. - "*i like that the caloric intake is easy to see and understand with the circle visual* ***i like the green and white colors***" [P11] – IND. - "***I like the sleek design of the app*** *a lot easy on the eyes*" [P16] – IND. - "***I like the interface the visuals the colors*** *It looks like a very innovative app*" [P26] – IND. - "***I like the idea of the app*** *and it looks like it would be useful It is something I would consider downloading*" [P42] – IND. - "***I like the general layout and aesthetic*** *and it feels modern and I generally like using it*" [P47] – IND. - "***I really dont like the stock photo***" [P52] – IND. - "***I like the layout***" [P55] – IND. - "*it looks useful and* ***i like the UI***" [P64] – IND. - "***I like the look of it***" [P66] – IND. - "***I like how it has a lot of information in one place***" [P116] – IND. - "*It looks nice* ***would probably motivate me to exercise sometimes***" [P142] – IND. - "***i like the green green makes me feel awake and ready***" [P158] – IND. - "***I like it*** *because it looks clean simple and easy to understand*" [P163] – IND. - "looks clean ***i like the green***" [P189] – IND.	8%	10%

Other Perceived UX Design Attributes/Constructs. Participants also made comments, which did not fall under any of the UX design-related themes (see Table 6.18). Such comments are either related to perceived enjoyment or are general comments/remarks. Examples of such general comments include: (1) "***No first impression***" made by a collectivist participant (P210); and (2) "***neutral impression***" made by an individualist participant (P108). Moreover, examples of comments related to perceived enjoyment include "***looks fun***" (P183) and "***the [a]pp looks interesting***" (P171).

Table 6.18: Participants' comments related to other perceived UX design attributes/constructs

Sample comments from collectivist and individualist participants on the PHA prototype	COL	IND
Other Perceived UX Attributes/Constructs - "*No first Impression*" [P210] – COL. - "*Indifferent, really*" [P250] – COL. - "*Just okay*" [P223] – COL. - "*neutral impression*" [P108] – IND. - "*It just seems like all the other apps out there*" [P120] – IND. - "*It seems like every other health app*" [P129] – IND. - "*i like the green green makes me feel awake and ready*" [P158] – IND. - "*to little information*" [P165] – IND. - "***Looks interesting*** *but not sure this is anything unique*" [P38] – IND. - "***Interesting*** *but Apple and Samsung already have an app installed*" [P62] – IND. - "***looks interesting***" [P166] – IND. - "***App looks interesting*** *but also reminds me of Black Mirror*" [P171] – IND. - "*It looks like* ***it could be a fun app***" [P139] – IND. - "***It looks fun***" [P183] – IND.	18%	16%

Table 6.19: Participants' comments related to adoption

Sample comments from collectivist and individualist participants on the PHA prototype	COL	IND
Adoption (Intention to Use) - "*It gives me my activity information but i would also* ***love to know exactly how to use it***" [P194] – COL. - "*Easy to use and* ***reduction of cost of hiring a trainer***" [P242] – COL. - "***I would love the app to be able to interface with other devices to collect data about my physical activities instead of entering data manually into the app***" [P209] – COL. - "*40 minutes might be* ***intimidating for newer people***" [P13] – IND. - "***I am interested in trying this app***" [P34] – IND. - "*It looks like* ***using it would be a positive experience***" [P36] – IND. - "*I like the idea of the app and it looks like it would be useful* ***It is something I would consider downloading***" [P42] – IND. - "***I like the general layout and aesthetic*** *and it feels modern and* ***I generally like using it***" [P47] – IND. - "***llooks like an app i would use***" [P97] – IND. - "***it looks like something that i would love to use***" [P99] – IND. - "***Probably wouldnt use it***" [P140] – IND. - "***Looks nice but not sure I would use am app***" [P180] – IND.	5%	5%

Adoption. Table 6.19 shows most of the participants' comments bordering on adoption of the fitness application. Approximately 5% of the participants in each culture expressed intentions to use or not to use the app if it were available to them. Regarding *intention to use*, P34 (an individualist participant) commented categorically, "***I am interested in trying this app.***" Similarly, P43 (another individualist participant) "***like[d] the idea of the app***" and thought "***it would be useful.***" Thus, P43 concluded, "***It is something I would consider downloading.***" Moreover, P209 (a collectivist participant) "***would love the app to be able to interface with other devices to collect data about my physical activities instead of entering data manually into the app.***" On the other hand, there are participants who suggested they might not adopt the application if deployed. For example, P140 commented, "***Probably wouldn[']t use it.***" Similarly, P180 commented, "***Looks nice but not sure I would use [the] app.***"

6.5.4 Discussion

I have presented a PHA's perception-to-adoption process model called "The Evaluative Process Model for Persuasive System Adoption" to uncover the UX design attributes and related constructs users care about when evaluating a PHA for the first time. I discuss the main findings in the light of S3b's subquestions.

UX Design Attributes that Make Users Want to Use a Persuasive System

Regarding the first subquestion (RQ3b-i), "*What UX design attributes make users want to use a PHA?*," Figure 6.10 shows the culture-specific profiles from the most to the least important UX design attributes/constructs. The thematic analysis of participants' comments showed that users, regardless of culture, care about *perceived aesthetics* (collectivist – 32.8 %, individualist – 42.3%) the most and *perceived credibility* (collectivist – 1.5 %, individualist – 6.3%) the least. It is interesting to find that, just as *perceived aesthetics* is among one of the two strongest UX design attributes that explain acceptance in the PTAM presented in Figure 6.8, so it is in the theme-based perception-to-adoption process model shown in Figure 6.10.

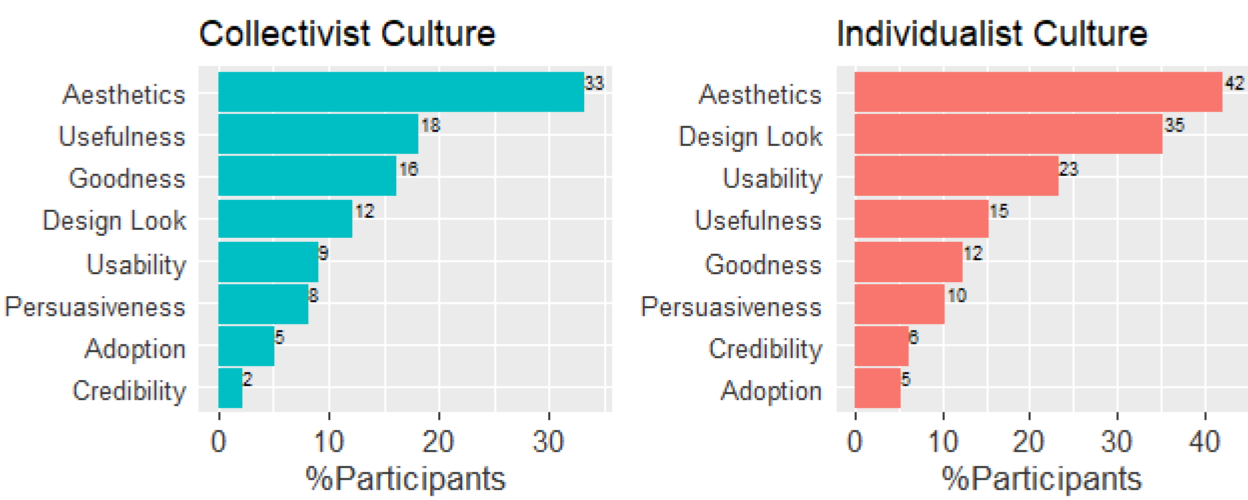

Figure 6.10: Culture-specific profile based on perceived UX design attributes and related constructs

Specifically, the finding that *perceived aesthetics* is the most predominant UX design attribute that grabs users' attention when they first come in contact with a PHA is consistent with the existing findings in website design [216][222][81]. Moreover, *perceived usefulness* (17.9%) and *perceived goodness* (16.4%) turned out to be the second and third most important UX design attributes, respectively, the collectivist participants care about. On the other hand, aside from *design look*, which is an abstract construct, *perceived usability* (22.8%) and *perceived usefulness* (14.8%) turned out to be the second and third most important UX design attributes, respectively, the individualist participants care about. Particularly, users, regardless of culture, care less about *perceived credibility*, which happens to be relegated to the background by *perceived aesthetics*.

Cultural Differences in Perceived UX Design Attributes and Adoption-Related Constructs

To answer the second subquestion, (RQ3b-ii),"*Are the UX design attributes moderated by culture?*," I have re-presented Table 6.10 in a graphical form (see Figure 6.11). This will help to uncover any form of trend in users' perceptions as we move from one end of the perception-to-adoption spectrum to the other. The spectrum ranges from "*perceived aesthetics*" through "*perceived usefulness*" to "adoption." Specifically, it will help to tease out or uncover any major differences or similarities between the two cultural groups in the perception-to-adoption process model. I have anticipated that users' perceptions and concerns, for the most part, will be focused on the "Evaluation/Judgment" phase (predominantly *perceived aesthetics*), followed by on the "Attitude" phase (*perceived persuasiveness*) and "Adoption" phase (*intention to use*). Once again, the reason for this expectation is that, the initial phase of the process model is based on visceral processing, which mostly deals with the character of the system (composed of hedonic/pragmatic attributes), while the later stage is based on reflective processing, which requires cognition as users relate their evaluation of the system to themselves and their experiences. In a nutshell, the later ("Attitude" and "Intention") phases are a consequence of the earlier ("Evaluation/Judgment") phase [236], which (i.e., the "Attitude" and "Intention" phases) some users may not reach in the process of evaluating a persuasive system.

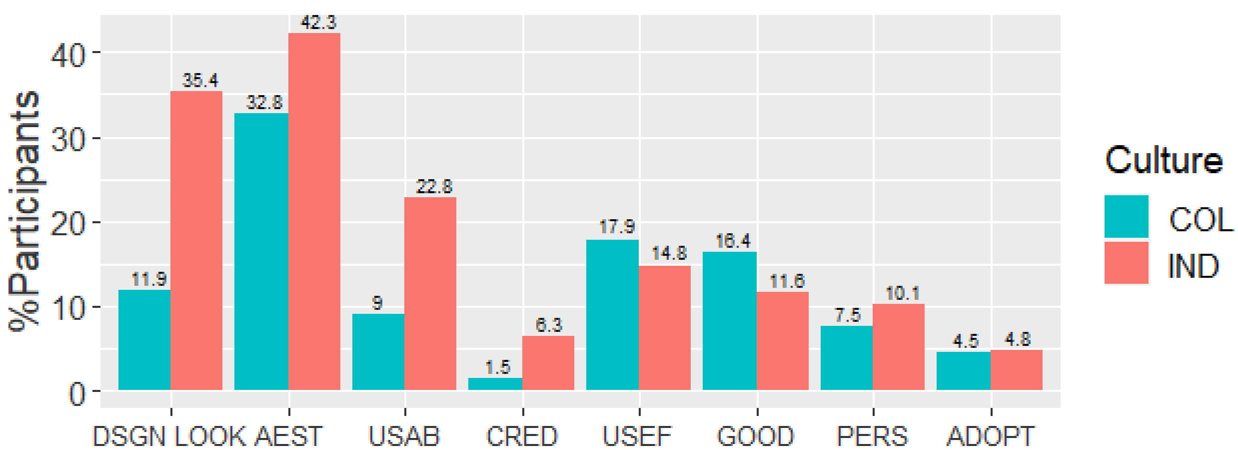

Figure 6.11: Graphical plot of the differences between collectivist and individualist cultures in their perception of UX design constructs in the process of evaluating a PHA. AEST = Perceived Aesthetics, USAB = Perceived Usability, CRED = Perceived Credibility, USEF = Perceived Usefulness, GOOD = Perceived Goodness, PERS = Perceived Persuasiveness, ACCEPT = Adoption.

As shown in Figure 6.11, beginning with *perceived aesthetics*, regardless of culture, there seems to be a decreasing trend in the frequency of perceived constructs moving from the left to the right side of the process model. For the individualist culture, aside from the dip brought about by *perceived credibility*, the bar charts from *perceived aesthetics* to adoption are in decreasing order. Specifically, excluding *design look*, *perceived aesthetics* (42.3%) turned out to be the most important UX design attribute individualist users care about, followed by *perceived usability* (22.8%), *perceived usefulness* (14.8%) and *perceived goodness* (11.6%). The later-phase constructs such as *perceived persuasiveness* (10.1%) and *intention to use* (4.8%), as expected, occur the least in the process model. Similarly, for the collectivist culture, aside from the dip brought about by *perceived usability* and *perceived credibility*, the trend from perception to adoption is in decreasing order. Excluding *design look*, *perceived aesthetics* (32.8%) turned out to be the most important UX design attribute collectivist users (just like individualist users) care about, followed by *perceived usefulness* (17.9%) and *perceived goodness* (16.4%). The later-phase constructs such as *perceived persuasiveness* (7.5%) and *intention to use* (4.5%) occur the least in the process model. Regardless of culture, *perceived aesthetics* and *perceived usefulness*, which are the strongest determinants of intention to use in the PTAM, turned out to be most prominent ($\geq$ 15%) in the thematic analysis of participants' comments. That said, the main difference between both cultures is that the individualist culture tends to care more about *perceived aesthetics*, *perceived usability* and *perceived credibility* than the collectivist culture. In contrast, the collectivist culture tends to care more about *perceived usefulness* and *perceived goodness* than the individualist culture.

Mediation of Persuasive System Adoption by *Perceived Persuasiveness*

This subsection provides an answer to the third subquestion (RQ3b-iii), *"Is there qualitative evidence in the target users' comments about the UI of the PHA that indicates that their intention to use it is mediated by perceived persuasiveness?"* In S3a, I showed that, in the individualist PTAM, *perceived persuasiveness* mediates the influence of *perceived usefulness* on *intention to use.* Moreover, in the thematic analysis of individualist participants' comments, there is supportive evidence. Figure 6.11 shows that 10.1 % of the individualist participants' comments border on *perceived persuasiveness.* This is an indication that *perceived persuasiveness* plays a mediating role in the adoption process, specifically between *perceived usefulness* and *intention to use.* Similarly, Figure 6.11 shows that 7.5 % of the collectivist participants' comments border on *perceived persuasiveness.* However, there is no quantitative evidence in the collectivist PTAM that indicates that the role played by *perceived persuasiveness* is a mediating one as in the individualist PTAM.

Triangulation of Quantitative Findings from S3a with Qualitative Findings from S3b

This subsection provides an answer to the fourth subquestion (RQ3b-iv), *"Do the qualitative findings in S3b provide empirical support for the quantitative findings in S3a?"*. Specifically, I triangulate the qualitative findings from S3b with the quantitative findings from S3a. Figure 6.12 and Figure 6.13 show the respective findings for the collectivist and individualist cultures, respectively.

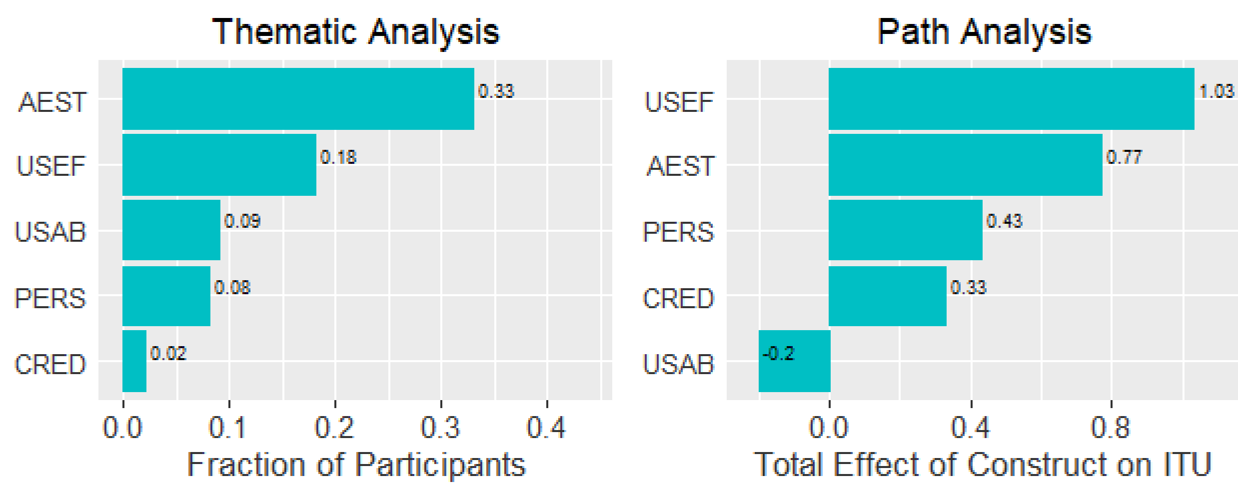

Figure 6.12: Collectivist triangulation of qualitative results (from S3b) and quantitative results (from S3a) on the UX design attributes users care about in a PHA. All of the total effects are significant at $p < 0.05$, except for PERS that is marginally significant ($p = 0.06$) and USAB that is non-significant.

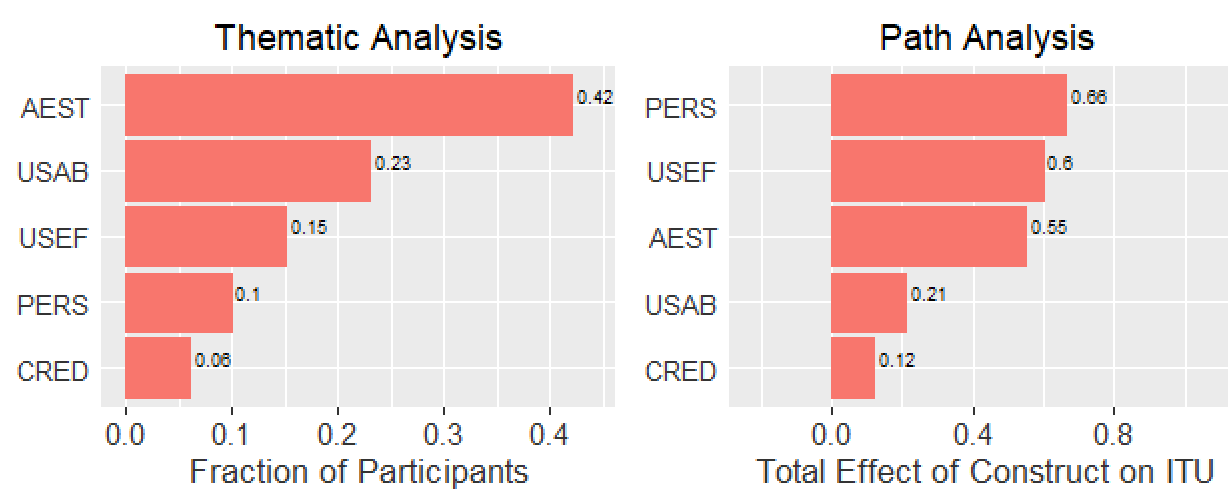

Figure 6.13: Individualist triangulation of qualitative results (from S3b) and quantitative results (from S3a) on the UX design attributes users care about in a PHA. All of the total effects are significant at $p < 0.05$.

Collectivist Culture Triangulation. As shown in Figure 6.12, for the collectivist culture, regardless of the method of analysis, *perceived aesthetics* and *perceived usefulness* turned out to be the most important UX design factors users consider when evaluating or making an intention to adopt a PHA. In the PTAM-based path analysis, the total-effect results showed that *perceived usefulness* ($\beta_T = 1.03$, $p < 0.001$) is stronger than *perceived aesthetics* ($\beta_T = 0.77$, $p < 0.001$). However, in the perception-to-adoption thematic analysis, the results showed that *perceived aesthetics* (32.8%) grabbed users' attention more than *perceived usefulness* (17.9%). A plausible explanation for the qualitative result is that users mostly make their evaluation at the visceral processing level, which is predominated by the visual appeal of the system. As I showed in the process model (Figure 6.9), in which we have *aesthetics* at the top-most level of the Evaluation/Judgment phase, it is expected that most of the participants' perceptions would be based on *visual aesthetics* (also known as *perceived aesthetics*). Prior research [216][223][244] in website design has shown that *perceived aesthetics* is the first port of call when users evaluate a website, including it's *perceived credibility*, which determines whether they will stay on the site or move to another. In sum, the relatively high percentage of participants' comments on *perceived aesthetics* (33%) and *perceived usefulness* (18%) is an indication that collectivist users consider both UX design attributes in their decision-making process, with *perceived aesthetics* being the first port of call for most collectivist users [216][223].

Moreover, in the PTAM-based path analysis, we see that *perceived credibility* ($\beta_T = 0.33$, $p < 0.001$) has a significant total effect on the *intention to use* a PHA, which, excluding *perceived persuasiveness*, is the third strongest UX design determinants of *intention to use* after *perceived usefulness* and *perceived aesthetics*. However, in the thematic analysis, *perceived credibility* (1.5%) comes in the fourth place, excluding *perceived persuasiveness*. The explanation for this finding is similar to that in the foregoing paragraph. In the qualitative evaluation of the PHA, *perceived aesthetics* and *perceived usability*, which are antecedents of *perceived credibility* [244], tend to prevent *perceived credibility* from coming to the fore, as shown in the Evaluation/Judgment phase (Figure 6.9). Although, among the UX design attributes, *perceived usefulness* is in the fourth position of the Evaluation/Judgment phase, given that it is one of the strongest determinants of *intention to use* in the PTAM (and in the TAM [58][269]), the collectivist participants tended to be very much concerned with it in the qualitative evaluation. This explains why, in terms of frequency, *perceived usefulness*, and not *perceived usability* or *perceived credibility*, is in the second place after *perceived aesthetics* in the evaluation process model. Finally, it is noteworthy that just as the PTAM-based path analysis showed that *perceived persuasiveness* is a proximal determinant of the *intention to use* a PHA ($\beta_T = 0.42$, $p = 0.06$), though not fully significant in the collectivist model, there is qualitative evidence of its involvement in the adoption process. Approximately 8% of the collectivist participants made comments related to *perceived persuasiveness*, indicating that it may play a role in the adoption of a PHA among certain collectivist users.

Individualist Culture Triangulation. As shown in Figure 6.13, for the individualist culture, regardless of method of analysis and excluding *perceived persuasiveness*, *perceived aesthetics*, *perceived usefulness* and *perceived usability* are the strongest UX design factors users consider when evaluating or making an intention to adopt a PHA. In the PTAM-based path analysis, *perceived usefulness* ($\beta_T = 0.66$, $p < 0.001$) turned out to be the strongest UX design determinant of *intention to use*, followed by *perceived aesthetics* ($\beta_T = 0.60$, $p < 0.001$), *perceived usability* ($\beta_T = 0.21$, $p < 0.001$) and *perceived credibility* ($\beta_T = 0.12$, $p < 0.001$). In the perception-to-adoption thematic analysis, up to 80% of the individualist participants' comments were related to first three UX design attributes. However, *perceived aesthetics* (42.3%) has a higher frequency than *perceived usefulness* (14.8%). Even *perceived usability* (22.8%) has a higher frequency than *perceived usefulness* (14.8%) as well. The explanations for these findings are two-fold. First, as depicted in the relative positions of the UX design attibutes in the Evaluation/Judgment phase of the process model (Figure 6.9), the *aesthetics- and usability-related* elements and/or attributes of the PHA are more likely to be perceived than its *usefulness-related* features. Second, unlike collectivist users, individualist users tend to care about *usability* as evident in the PTAM-based findings, where *perceived usability* has an overall effect on *intention to use* for the individualist culture (β_T = 0.21, $p < 0.001$), but not for the collectivist culture (β_T = -0.20, $p = n.s$). Thus, in the qualitative evaluation of the PHA, we see *perceived usability* (22.8%) being second to *perceived aesthetics* (42.3%) in terms of frequency. Finally, in the individualist PTAM, we see that *perceived persuasiveness* is a significant proximal determinant of the *intention to use* a PHA (β_T = 0.60, $p < 0.001$). Particularly, it acts as a partial mediator of the influence of *perceived usefulness* on *intention to use*. There is supportive evidence for this quantitative finding in the thematic analysis. Approximately 10% of their comments related to *perceived persuasiveness*, indicating that it plays a mediating role in the adoption of a PHA among a number of individualist users.

Importance of Perceived Aesthetics and Perceived Usefulness in the Adoption of a PHA. In both studies (S3a: a quantitative study and S3b: a qualitative study), I showed that *perceived aesthetics* and *perceived usefulness* are among the most important UX design attributes users care about, regardless of culture and study method (quantitative or qualitative). Moreover, in triangulating the qualitative findings from S3b with the quantitative findings from S3a, I found evidence that supports Hassenzahl's [236] postulation on the desirability of a product. The postulate states that if both the hedonic (affective) and utilitarian (pragmatic) attributes of a HCI system are perceived as high, then the system is desired by the user, meaning the user finds the system persuasive and may be willing to adopt it. In the context of PHAs aimed at behavior change, the hedonic and utilitarian attributes can be regarded as *perceived aesthetics* and *perceived usefulness*, respectively. I found supporting quantitative evidence in the PTAM (S3a) and qualitative evidence in the thematic analysis (S3b) indicating that high perceptions of *aesthetics* and *usefulness* are likely to result in a high *perceived persuasiveness* of the PHA and *intention to use* it.

For example, in S3a and S3b, regarding the PHA prototype, a collectivist participant (P237) that commented, "*I like the interface and the daily tip*," rated both the *perceived aesthetics* (6.2/7) and the *perceived usefulness* (6.5/7) of the PHA high. These high ratings of both hedonic and pragmatic attributes must have impacted the participant's mean rating of the *perceived persuasiveness* of the PHA (6/7) and the *intention to use* it (6/7). The high ratings for all four constructs are evident in their significant interrelationships in the collectivist PTAM shown in Figure 6.6. Similarly, an individualist participant (P5) that commented, "*I like the overall design of the home page*," rated both the *perceived aesthetics* (5/7) and the *perceived usefulness* (6.25/7) of the PHA high. Again, the high ratings of both types of attributes must have impacted the participant's mean rating of the *perceived persuasiveness* of the PHA (5.75/7) and the *intention to use* it (6/7). The high ratings for all four constructs are evident in their significant interrelationships in the individualist PTAM shown in Figure 6.7. Therefore, in the context of UX, PT designers should prioritize the *perceived aesthetics* and *perceived usefulness* of their PHAs to increase the adoption rate by potential users.

6.6 S3c: Investigation of the Persuasive Design Determinants of the Use of a PHA among the Target Audience and the Moderating Effect of Culture: a Quantitative Approach

Persuasive (design) features are supportive/motivational features with which persuasive applications are equipped to motivate behavior change of users. While S3a investigated the UX design attributes that determine the *acceptance* of a PHA, the current investigation (S3c) examines the persuasive design features that determine the *use* of a PHA. With regard to the Technology Adoption Model shown in Figure 2.4, apart from UX design attributes, I anticipate that persuasive design features can predict users' *intention to use* a PHA as well. The reason for this anticipation is that, in S3a, *perceived usefulness*, which is a pragmatic/utilitarian construct, has a significant influence on the *intention to use* a fitness app. Specifically, *perceived usefulness* can be regarded as a proxy for the persuasive features of a PHA, which motivate and facilitate the performance of the target behavior. Hence, in the current investigation (S3c), I set out to examine the role persuasive features (such as Goal-Setting/Self-Monitoring, Reward, Cooperation, Social Learning, Social Comparison and Competition) play in the adoption process and the moderating effect of culture.

6.6.1 Research Questions

Formally, this investigation (S3c) aims to address the following research question (RQ3c), "*Using the PTUM, which of the common persuasive design features are the strongest determinants of the use of a PHA and how are they moderated by culture?*" The research question is broken into its constituent parts as follows:

RQ3c-i. Which of the six commonly known persuasive design features is/are the strongest determinants of the *intention to use* a PHA?

RQ3c-ii. Are the relationships between the persuasive design features and *intention to use* moderated by culture?

6.6.2 Research Model and Hypotheses

Due to the paucity of research on the topic, especially cross-cultural, I adopted an exploratory approach (Figure 6.14) to investigate the relationships between the six persuasive features and the *intention to use* a PHA, and how the two cultures significantly differ. (See Table 6.2 for the quantitative measures of the constructs in the exploratory model.)

6.6.3 Data Analysis

I employed PLSPM to determine which of the relationships in the hypothesized model is significant in each culture. Secondly, I employed a multigroup analysis to uncover how the two cultures significantly differ.

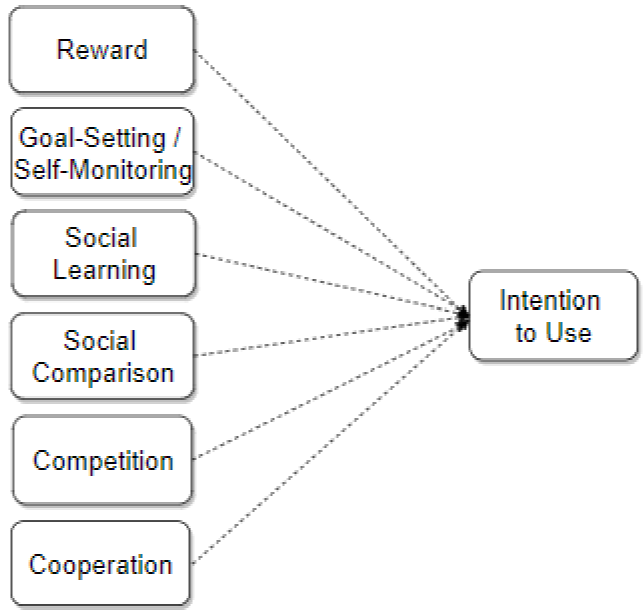

Figure 6.14: Exploratory persuasive technology use model based on persuasive design features

Evaluation of the Measurement Models

Prior to analyzing the culture-specific structural models, I assessed the measurement models in order to ensure that the preconditions (the criteria for analyzing the structural models) were met [74][170]. The preconditions, their definitions and the overall results of the evaluation of the measurement models are shown in Table 6.3. They include indicator reliability, internal consistency reliability, convergent validity and discriminant validity. All of the criteria for building and analyzing the structural models were met. For example, regarding indicator reliability, the loading of the items on each construct in the culture-specific measurement models is greater than 0.7.

Structural Analysis of the Culture-Specific Models

Figure 6.15 shows the culture-specific PTUM models. In the collectivist model, the GOF and R^2 values are 77% and 67%, respectively. Similarly, in the individualist model, the GOF and R^2 values are 79% and 68%, respectively. Both the GOF and R^2 values are high, regardless of culture [74][187]. The GOF value of over 70% is an indication that both models fit their respective empirical data well. Moreover, the R^2 value of over 60% is an indication that the significant persuasive features explain a large portion of the variance of *intention to use*. Specifically, Goal-Setting/Self-Monitoring, which explains most of the variance of *intention to use*, turns out to be the strongest determinant for both the collectivist ($\beta = 0.49$, $p < 0.001$) and individualist ($\beta = 0.43$, $p < 0.001$) cultures. Moreover, for the individualist culture, Competition ($\beta = 0.28$, $p < 0.001$) and Reward ($\beta = 0.18$, $p < 0.05$) have a significant effect on *intention to use*. However, the multigroup analysis shows that there is no significant difference between both models with regard to all six relationships.

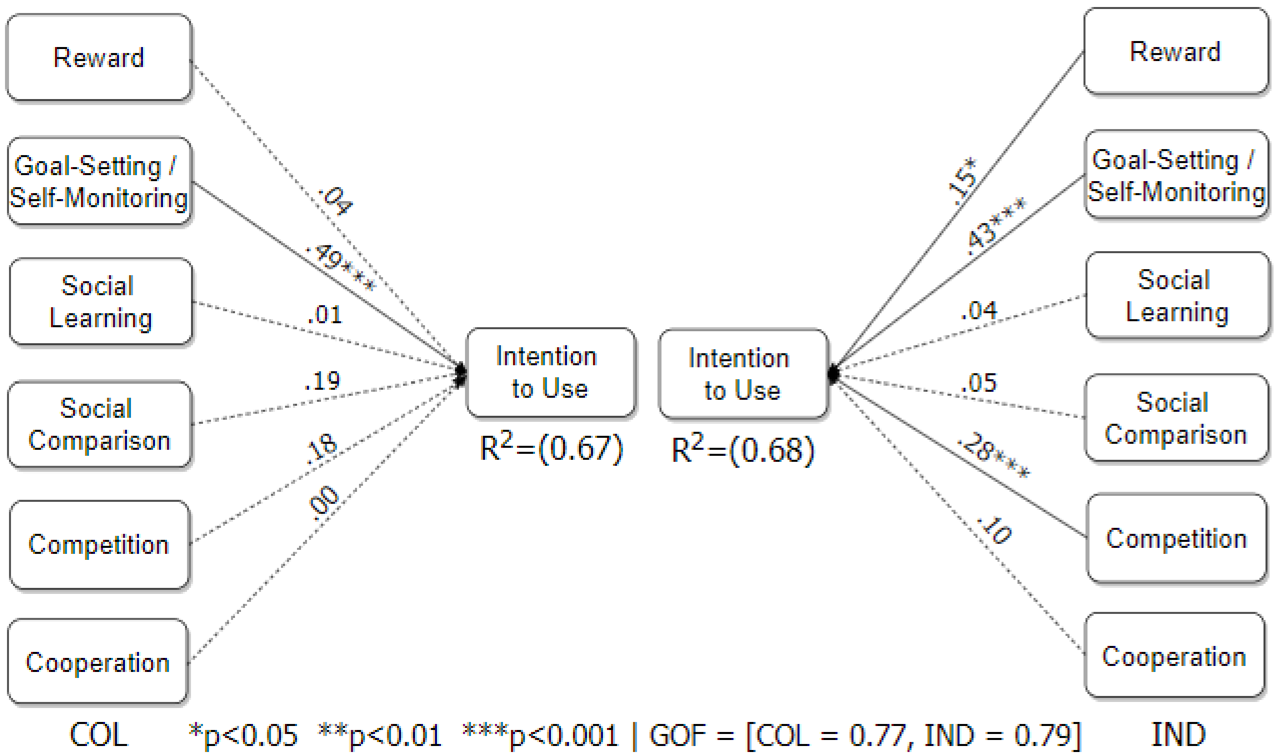

Figure 6.15: Culture-specific persuasive technology use model based on persuasive design features

Effect Size and Cultural Difference

Table 6.20 shows the size of effect of the persuasive features on *intention to use*. Goal-Setting/Self-Monitoring has a large and a medium effect size on *intention to use* in the individualist model ($f^2 = 0.35$) and collectivist model ($f^2 = 0.26$), respectively. Specifically, in the individualist model, Reward and Competition have a small effect size on *intention to use*, but a non-significant effect size in the collectivist model.

Table 6.20: Effect size of persuasive constructs on intention to use. $f^2 = 0.02$: small, $f^2 = 0.15$: medium, $f^2 = 0.35$: large [72]. R^2_{inc} and R^2_{exc} are the coefficients of determination when the persuasive construct is included and excluded from the model, respectively. The bold effect size is large.

	COL			**IND**		
Persuasive Construct	R^2_{inc}	R^2_{exc}	f^2	R^2_{inc}	R^2_{exc}	f^2
GOAL/SMT	0.67	0.59	0.26	0.68	0.57	**0.35**
REWD	0.67	0.67	-0.01	0.68	0.66	0.05
CMPT	0.67	0.66	0.02	0.68	0.64	0.13
COOP	0.67	0.67	-0.01	0.68	0.67	0.03
SLEARN	0.67	0.67	-0.01	0.68	0.68	0.01
SCOMP	0.67	0.66	0.02	0.68	0.67	0.02

6.6.4 Discussion and Summary of Findings

In S3c, I presented a model of the persuasive features that explain the use of a PHA. Specifically, based on a subset of six commonly employed persuasive features (Goal-Setting/Self-Monitoring, Reward, Cooperation, Social Learning, Social Comparison and Competition), I showed the features that have a significant influence on the *intention to use* a fitness app. Table 6.21 shows the results in decreasing order of strength.

Table 6.21: Culture-specific profile based on the persuasive design determinants of the intention to use a PHA. The underlined construct indicates it has a significant total effect on intention to use, with solid and dashed lines representing strong ($\beta \geq 0.2$, $p < 0.05$) and weak effects, respectively. The brackets indicate the numerical difference between each pair of bracketed constructs is less than 0.05.

Model	**Order of Strength of Determinants of Intention to Use**
Collectivist	GOAL/SMT, [SCOMP, CMPT], [REWD, SLEARN, COOP]
Individualist	GOAL/SMT, CMPT, REWD, COOP, [SCOMP, SLEARN]

Regardless of culture, Goal-Setting/Self-Monitoring ($\beta > 0.40$, $p < 0.001$) turns out to have the strongest influence on *intention to use*, with a large and medium effect size in the individualist and collectivist models, respectively. This is followed by Competition ($\beta = 0.24$, $p < 0.01$) and Reward ($\beta = 0.14$, $p < 0.05$) with regard to the individualist model, with each feature having a small effect size. Unfortunately, Social Comparison and Social Learning have no significant influence in both culture-specific models.

In the light of the two subquestions (RQ3c-i and RQ3c-ii) of S3c, the results suggest that, regardless of culture, Goal-Setting/Self-Monitoring is the most important driver of the *intention to use* a PHA to motivate behavior change. This finding is consistent with the quantitative finding in S2a that, regardless of culture, users are most likely to be receptive to Goal-Setting/Self-Monitoring. Moreover, this finding reflects the finding in S3a that *perceived usefulness* is one of the two strongest determinants of the *intention to use* a PHA. This suggests that a useful PHA is one that supports at least Goal-Setting/Self-Monitoring. Hence, given that users are more likely to be receptive to Goal-Setting/Self-Monitoring than other commonly employed persuasive features (S2a) and it is the strongest determinant of *intention to use* (S3c), it can be regarded as an essential feature of a PHA aimed at changing behavior. Even the operationalization of *perceived usefulness* in S3a reflects the importance of Goal-Setting/Self-Monitoring. For example, as shown in Table 6.1, one of the items of *perceived usefulness* states that "*the app will help me accomplish my exercise goal.*" Another item states that "*the app will make it easier to reach my exercise goals.*" Due to the possible relationship between *perceived usefulness* and Goal-Setting/Self-Monitoring, I conclude that every minimally viable PHA, regardless of the culture of the target users, should implement at least the Goal-Setting/Self-Monitoring feature. Goal-Setting/Self-Monitoring, to which most users, regardless of culture, are receptive, can influence potential users' decision to adopt a PHA to motivate their behavior change.

6.7 S3d: Investigation of the Key Supportive/Persuasive Features that Make the Target Audience Want to Use a PHA and the Moderating Effect of Culture: a Qualitative Approach

In this examine (S3d), I investigate the key features in a PHA that users care about and the moderating effect of culture using a qualitative approach. The investigation is a follow-up to S3c, in which I investigated the most important persuasive design determinants of the *intention to use* a PHA using a quantitative approach.

6.7.1 Research Questions

This investigation (S3d) aims to address the following research question (RQ3d), "*What are the key features of a PHA users care about and how are they moderated by culture?*" The research question is broken into its constituent parts as follows:

RQ3d-i. What key supportive/persuasive features make users want to use a PHA?

RQ3d-ii. Are the key supportive/persuasive features moderated by culture?

RQ3d-iii. Do the qualitative findings in S3d provide empirical support for the quantitative findings in S3c?

6.7.2 Data Analysis

To provide answers to the three subquestions, I conducted a thematic analysis on the study participants' responses to the open question, "*Please enter here [textbox provided] one key feature you would expect the app to have if you were to use it.*" This question is with regard to the PHA prototype shown in Figure 6.2.

6.7.3 Results

In this section, I present the results of the thematic analysis of the comments provided by participants regarding the key features they would want a PHA aimed at motivating behavior change to have.

Key Features Participants Care About

Table 6.22 shows the most preferred features that the participants expected a PHA to have. Specifically, it shows the percentage of participants in the overall population and culture-specific groups that expressed preference for each of the 17 teased-out features in the thematic analysis. It also shows the cultural difference with respect to the percentage of participants in each culture that requested each feature. Overall, Self-Monitoring (41.0%) and Reminder/Notification (10.2%) are the most requested key features, while Scheduler/Planner (1.2%) and Exercise Statistics (1.2%) are the least requested key features. In the collectivist culture, Reminder/Notification (28.4%) and Self-Monitoring (23.9%) are the most requested key features, while Summary Statistics (0%) and Exercise Statistics (0%) are the least requested key features. Finally, in the individualist culture, Self-Monitoring (47.1%) and Exercise Timer (8.5%) are the most requested key features, while Tailoring/Customization (0.5%) is the least requested key feature.

Table 6.22: Percentage of participants in each culture that wanted a certain feature in a PHA

No.	Feature	Overall	COL	IND	%DIFF
1	Self-Monitoring	41.0	23.9	47.1	-23.2
2	Reminder/Notification	10.2	28.4	3.7	24.7
3	Behavior Model	8.6	9.0	8.5	0.5
4	Goal-Setting	4.7	1.5	5.8	-4.3
5	Exercise Timer	4.7	6.0	4.2	1.7
6	Workout Plan/Routine	3.9	3.0	4.2	-1.2
7	Suggestion/Recommendation	3.5	7.5	2.1	5.5
8	Exercise Tips	3.1	3.0	3.2	-0.2
9	List of Exercise	2.7	1.5	3.2	-1.7
10	Reward	2.7	4.5	2.1	2.4
11	Social Support	2.3	3.0	2.1	0.9
12	Goal/Calorie/Data Input	2.3	1.5	2.6	-1.2
13	Motivational Quotes	2.3	3.0	2.1	0.9
14	Exercise Statistics	1.6	0.0	2.1	-2.1
15	Tailoring/Customization	1.6	4.5	0.5	4.0
16	Scheduler/Planner	1.2	0.0	1.6	-1.6
17	Exercise History	1.2	0.0	1.6	-1.6

Sample Comments Relating to the Key Features Participants Care About

Table 6.23 shows all of the key features requested by the study participants together with sample comments supporting each feature. For example, sample comments related to Self-Monitoring, which is the most and second most requested features in the individualist and collectivist cultures, respectively, include: (1) "***How many calories lost***" by P227 (a collectivist participant); and (2) "*Easy user interface to* ***track and monitor workouts***" by P176 (an individualist participant). Moreover, regarding Reminder/Notification, the second and third most requested feature in the collectivist and individualist groups, respectively, sample comments include: (1) "***A persuading reminder*** *on time to exercise daily*" by P197 (a collectivist participant); and (2) "***Push notifications*** *to let me know if I am falling behind my weekly target*" by P146 (an individualist participant).

Table 6.23: Culture-specific key features users want in a persuasive health application.

Requested features with examples of participants' comments	COL	IND
KF1. Self-Monitoring - "*The app should be able to* ***monitor*** *my physical activities*" [P213] – COL. - "*Be able to* ***calculate my BMI at intervals***" [P191] – COL. - "***Monitoring my progress***" [P199] – COL. - "***Weight loss***" [P200] – COL. - "***Track record for my fitness***" [P247] – COL. - "***How many calories lost***" [P227] – COL. - "***BMI calculator***" [P239] – COL. - "***A calorie counter*** *to help you lose weight and keep track of the foods you eat*" [P16] – IND. - "***exercise tracking*** *like to track reps and weights*" [P55] – IND. - "***Ability to track my activity level***" [P61] – IND. - "*Easy user interface to* ***track and monitor workouts***" [P176] – IND. - "*A large variety of* ***goals you can track***" [P122] – IND. - "***Heart rate monitor***" [P157] – IND. - "***Step counter and goal***" [P139] – IND. - "***nutrition tracker***" [P164] – IND. - "***Weight tracker***" [P153] – IND.	24%	47%
KF2. Reminder/Notification - "***A persuading reminder on time to exercise daily***" [P197] – COL. - "***To have a reminder****. So the users can actually set a convenient time for the exercise*" [P201] – COL. - "*The app should be able to* ***remind of exercising***" [P205] – COL. - "***Reminder for normal time of exercise***" [P219] – COL. - "***An alarm clock***" [P229] – COL. - "***Configuring Notification***" [P197] – COL. - "***Timely reminders***" [P255] – COL. - "***A warning alarm or notification*** *if I missed an exercise in a day*" [P234] – COL. - "***A daily reminder to exercise*** *and amount of calories lost*" [P257] – COL. - "***Reminders about when sessions should be done***" [P119] – IND. - "***Consistent reminder from the app to work out*** *and motivational quotes or pics to follow with reminder*" [P121] – IND. - "*Ability to plan what days you want to exercise ie every second day then* ***being notified on those days***" [P142] – IND. - "***Push notifications*** *to let me know if I am falling behind my weekly target*" [P146] – IND.	28%	4%
KF3. Behavior Model - "***Video showing how to exercise***" [198] – COL. - "***Exercise videos that benefit a particular part of the body*** *and duration of such exercise in a day to achieve its purpose*" [P242] – COL. - "***Teach me how to exercise***" [P252] – COL. - "***Different exercise patterns*** *for different workout purpose*" [P230] – COL. - "*I would expect it to list a variety of different exercises to choose from and have a little* ***information about how to perform the exercise*** *and how many calories each exercise burns*" [P42] – IND.	10%	8%

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Table 6.23 – *Continued from previous page*

Requested features with examples of participants' comments	COL	IND
- "***Videos that you can follow along*** *and exercise to with increasing difficulty such as strength yoga or treadmill workouts*" [P111] – IND. - "***Videos showing how to preform exersizes***" [49] – IND. - "***Good instructions for recommended exercises***" [P13] – IND.		
KF4. Exercise Timer - "*i will like the app to* ***have adequate timing for a particular type of exercise***" [P192] – COL. - "***Timing of my physical activity***" [P193] – COL. - "*The app should be able to* ***monitor how long I exercise***" [P204] – COL. - "***Timer***" [P201] – COL. - "***timer for exercises***" [P41] – IND. - "***time intervals for reps and sets***" [P123] – IND. - "***time spent excercising***" [P1] – IND. - "***Time tracker***" [P160] – IND.	6%	5%
KF5. Goal-Setting - "*Tailored* ***goal setting*** *based on physical index input*" [P195] – COL. - "***The ability to define goals***" [P24] – IND. - "*I would expect it to* ***allow me to change my goals*** *as my needs change*" [P36] – IND. - "***my goals for the week***" [P46] – IND. - "***A large variety of goals*** *you can track*" [P22] – IND.	2%	6%
KF6. Workout Plan/Routine - "*Customization of exercise routine with* ***detailed explanation of each routine*** *and its benefits*" [P194] – COL. - "*Basically,all necessary* ***gym programs***" [P248] – COL. - "***balanced exercise routine*** *showing purpose of each exercise*" [P3] – IND. - "*It would contain* ***workout routines or goals*** *that are able to be met with no or very little equipment and at home*" [P145] – IND. - "***Workout plan examples***" [P130] – IND. - "***Customized workout plans***" [P138] – IND.	3%	4%
KF7. Suggestion/Recommendation - "***Sample that will show me the type of exercise that is fit for a pregnant woman or nursing mother***" [P208] – COL. - "***The exercise that fit my body shape***" [P225] – COL. - "***Meal expected to eat while trying to achieve the size***" [P253] – COL. - "***Good instructions for recommended exercises***" [P13] – IND. - "***Suggest weekly routine***" [P147] – IND. - "*to* ***provide food opinion***" [P91] – IND. - "***goal list***" [P57] – IND.	7%	2%
KF8. Exercise Tips - "***Tips on healthy living***" [P210] – COL. - "***Meal advice*** *based on users target*" [P220] – COL. - "***Exercise tips*** *for specific exercises*" [P53] – IND.	3%	3%

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Table 6.23 – *Continued from previous page*

Requested features with examples of participants' comments	COL	IND
- "***Exercise tips***" [P83] – IND. - "***Daily exercise ideas***" [P150] – IND. - "***Very detailed instructions about the exercises and how to do them***" [P152] – IND.		
KF9. List of Exercise - "***Different exercise patterns for different workout purpose***" [P230] – COL. - "*I would expect the app to have* ***different exercise options*** *that you could choose to do and track*" [P5] – IND. - "***List of exercises***" [P40] – IND. - "*I would expect it to* ***list a variety of different exercises to choose from*** *and have a little information about how to perform the exercise and how many calories each exercise burns*" [P42] – IND. - "***Targeted exercises for different body parts***" [P44] – IND. - "***Multiple exercises you can do in your home***" [P56] – IND.	3%	3%
KF10. Reward - "*i would suggest the app has a way of monitoring people that keep to their fitness routine and if its done for a period of time,* ***the person wins a free massage at a spa*** *or a free gym workout in the neighbourhood*" [P206] – COL. - "***Words of encouragement for progress made***" [P222] – COL. - "***converting Calories to cash***" [P249] – COL. - "***rewards***" [P31] – IND. - "***Points system***" [P172] – IND. - "*I would use it if there were* ***some kind of incentive such as points*** *for the rewards cards I use*" [P103] – IND.	5%	2%
KF11. Social Support (adding users, chat, leaderboard, social comparison) - "***Chat***" [P226] – COL. - "***A chat forum***" [P241] – COL. - "*The ability to* ***add friends for support***" [P8] – IND. - "***A chart that compares*** *how well i did compared to others*" [P54] – IND. - "*something useful beyond motivation and tracking as I have no difficulties with either period here scaling and* ***useful tools for groups would be nice***" [P124] – IND. - "*I like to see and* ***compare my results with others***" [P132] – IND.	3%	2%
KF12. Goal/Calorie Data Input - "*There should be* ***a window where i will input my daily challenge*** *and get feedback on it*" [P237] – COL. - "*I would expect it to* ***allow me to change my goals as my needs change***" [P36] – IND. - "***A way to count calories by entering what i ate for the day***" [P52] – IND. - "***A place for me to put the kind of exercise*** *I wanted to do*" [P66] – IND. - "***Ability to add calories***" [P79] – IND. - "***A place to enter my daily caloric intake***" [P163] – IND.	2%	3%
KF13. Motivational Quote - "*Alarm and* ***motivational quotes***" [P232] – COL. - "***Words of encouragement*** *for progress made*" [P222] – COL.		

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Table 6.23 – *Continued from previous page*

Requested features with examples of participants' comments	**COL**	**IND**
- "***motivational quotes***" [P64] – IND. - "***give some motivation daily***" [P118] – IND. - "***Some type of motivation** or motivator*" [P135] – IND. - "***Motivational phrases***" [P154] – IND.	3%	2%
KF14. Summary Statistics - "***monthly goal statistics***" [P23] – IND. - "***statistics***" [P88] – IND. - "***The ability to track statistics and progress***" [P156] – IND.	0%	2%
KF15. Tailoring/Customization - "***Tailored goal setting based on physical index input***" [P195] – COL. - "***Customization of exercise routine** with detailed explanation of each routine and its benefits*" [P194] – COL. - "*Wouldn't want it to be a one size fits all app.. **It can be tailored to the initial Bmi of the user***" [P254] – COL. - "***Customized workout plans***" [P138] – IND.	5%	1%
KF16. Exercise Scheduler/Planner - "*The most important key feature would have to be **being able to schedule my routine** and having reminders as well*" [P25] – IND. - "***workout planner***" [P112] – IND. - "***Ability to plan what days you want to exercise** ie every second day then being notified on those days*" [P142] – IND.	0%	2%
KF17. Exercise History - "*I would expect it to have a screen that has more detailed information like **a listing of days I exercised** and how much time I spent on which exercise*" [P50] – IND. - "***Historical data to see how much exerce** I do each day*" [P137] – IND.	0%	2%

6.7.4 Discussion

In this section, I discuss the key application features, how they differ between the two cultures and their implication for PHA design.

Key Features and Empirical Evidence to Support Participants' Preference

In this subsection, I discuss the five most important application features shown in Table 6.23 and Table 6.22.

Self-Monitoring. Self-monitoring turned out to be the most important feature for the overall population. The participants want to be able to track their physical activity, including goals, calorie burned, calorie intake, weight loss, BMI, heart rate, etc. It is the most important feature for the individualist group (47%) and second most important feature for collectivist group (24%). Sample comments supporting the participants' preference for this feature are shown in Table 6.23. For example, in the individualist group, P176 commented that the most important key feature for him is an "*Easy user interface to **track and monitor workouts.***" Similarly, in the collectivist group, P213 remarked, "*The app should be able to **monitor my physical activities.***"

Reminder/Notification. The second most important feature for the overall population is Reminder/Notification. About 29% of the collectivist and 4% of the individualist participants requested it. For example, among the collectivist participants, P197 commented that he would need a "***persuading reminder on time to exercise daily.***" Similarly, P201 requested to "***have a reminder. So the users can actually set a convenient time for the exercise.***" Among the individualist participants, P142 wanted the "*[a]bility to plan what days you want to exercise ie every second day then* ***being notified on those days.***" Specifically, P146 wanted "***[p]ush notifications to let me know if I am falling behind my weekly target.***"

Behavior Model. The third most important feature for the overall population is Behavior Modeling, which could be in the form of instructions and/or video showing how a certain exercise behavior can be correctly performed. The number of participants from both cultures that wanted this feature are not widely different (10% of the collectivist participants and 8% of the individualist participants). For example, among the collectivist participants, P242 commented that he would want "***Exercise videos that benefit a particular part of the body*** *and duration of such exercise in a day to achieve its purpose.*" Similarly, P30 requested to have illustrations of "***Different exercise patterns*** *for different workout purpose.*" Among the individualist participants, P42 commented she would expect to be provided with a "*list [of] a variety of different exercises to choose from and have a little* ***information about how to perform the exercise*** *and how many calories each exercise burns.*" Finally, P111 expected to have "***Videos that you can follow along*** *and exercise to with increasing difficulty such as strength yoga or treadmill workouts.*"

Exercise Timer. The fourth most important feature for the overall population is Exercise Timer. The number of participants from both cultures that wanted this feature are not widely different (6% of the collectivist participants and 5% of the individualist participants). For example, among the collectivist participants, P204 commented that he expected "*[t]he app should be able to* ***monitor how long I exercise.***" Similarly, among the individualist participants, P160 commented that she wanted a "***[t]ime tracker***," while P123 requested the provision of "***time intervals for reps and sets***" by the fitness app.

Goal-Setting. The fifth most important feature for the overall population is Goal-Setting. This feature resonated more with the individualist participants (6%) than the collectivist participants (2%). For example, among the collectivist participants, P195 commented that he wanted to be able tailor his goals through "***goal setting*** *based on physical index input.*" Moreover, among the individualist participants, P36 commented that she expected the fitness application "*to* ***allow me to change my goals*** *as my needs change.*"

Other Requested Features. Other features requested by the study participants (see Table 6.23) include Workout Plan/Routine, Suggestion/Recommendation, List of Exercise, Reward, Social Support, Goal/Calorie Data Input, Motivational Quotes, Summary Statistics, Tailoring/Customization, Scheduler/Planner and Exercise History. Except for Suggestion/Recommendation and Tailoring/Customization, which a higher percentage of the collectivist participants than the percentage of the individualist participants requested, the percentage difference between both cultural groups is little to nothing.

Cultural Differences in the Preferred Key Features of a Persuasive Health Application

The thematic analysis shows that there are cultural differences in the participants' key-feature preferences. Table 6.22 shows that there are five major differences between the two cultural groups in terms of their preferred key features. These differences are represented graphically in Figure 6.16.

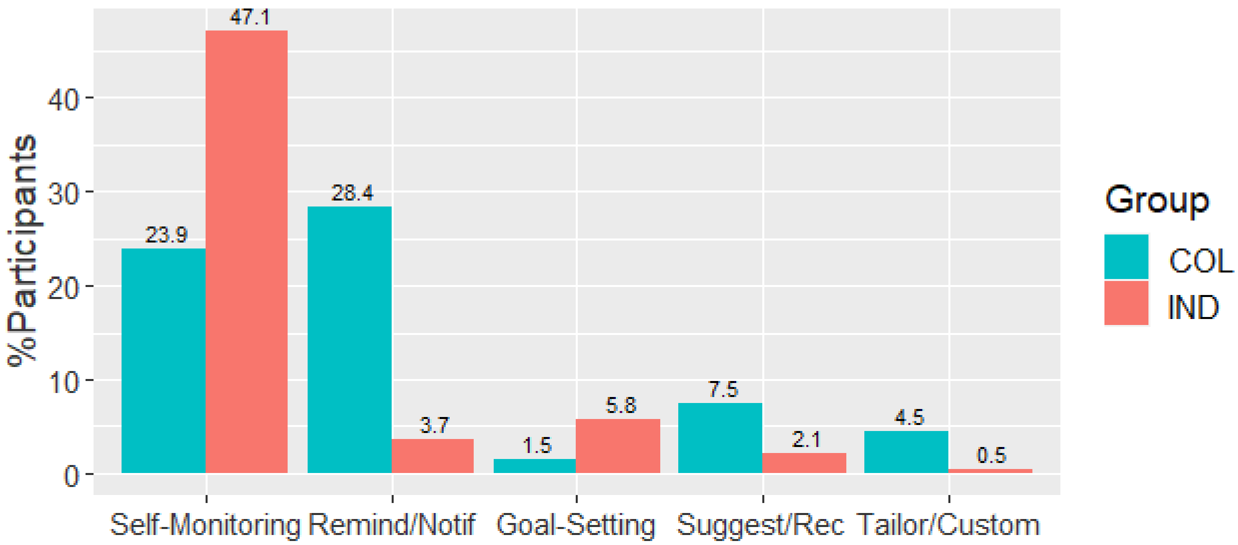

Figure 6.16: Key features in which collectivist and individualist cultures differ by at least 3%

The highest difference between both cultures (17.1%) is with respect to Self-Monitoring, for which the individualist group (47.1%) expressed a higher preference than the collectivist group (23.9%). The individualist group's higher preference for the Self-Monitoring feature than the collectivist group's can be explained using the notion of independence in Hofstede's [131] individualism vs. collectivism dimension. Based on this notion, individualist cultures are more likely to be independent and self-driven. In line with this notion, Figure 6.16 shows that the Canadian/American group desires the Self-Monitoring feature (in a personal setting) more than the Nigerian group. This qualitative finding is consistent with the quantitative finding in S2a (Table 5.3), in which I found that the Canadian/American group, based on the ranking measure, is more likely to be receptive to the Goal-Setting/Self-Monitoring feature, although the numerical ranking difference between both cultures is not significant ($p = 0.085$). Secondly, the current qualitative finding is consistent with the prior qualitative finding in S2b (Table 5.11), in which the Canadian/American group (+39%) provided more overall favorable comments on Goal-Setting/Self-Monitoring than the Nigerian group (+24%).

The second highest difference between both cultures (24.7%) is with respect to Reminder/Notification, for which the collectivist group (28.4%) expressed a higher preference than the individualist group (3.7%). The fact that the collectivist group has a higher preference for the Reminder/Notification feature than the individualist group can be explained using the notion of interdependence in Hofstede's [131] individualism vs. collectivism dimension. Based on this notion, collectivist cultures are more likely to be interdependent and require social support. Consistent with this notion, the Nigerian collectivist group is more likely than the Canadian/American individualist group to require external support in the form of reminder to exercise or notification when their collaborative partners achieve their health goal or a milestone. Moreover, the current qualitative finding is consistent with the quantitative finding in S2a, in which I found that the Nigerian collectivist group is more likely to be receptive to Cooperation and Social Learning than the Canadian/American individualist group. Secondly, the current qualitative finding is consistent with the prior qualitative finding in S2c, in which the Nigerian collectivist group provided overall positive comments on the social features (+14%), while the Canadian/American group provided overall negative comments (-13%).

The third highest difference between both cultures (4.3%) is with respect to Goal-Setting, for which the individualist group (5.8%) expressed a higher preference than the collectivist group (1.5%). The explanation for this cultural difference is the same as that for Self-Monitoring, especially given that Self-Monitoring and Goal-Setting are complementary features.

The fourth highest difference between both cultures (5.4%) is with respect to Suggestion/Recommendation, for which the collectivist group (7.5%) expressed a higher preference than the individualist group (2.1%). As regarding Reminder/Notification, this cultural difference can be explained using the Hofstede's notion of interdependence among people of collectivist cultures. Hence, in the current study, due to the Nigerian collectivist group's interdependence, it is more likely to require social or external support (in this case, suggestions and recommendations from the PHA serving as a social actor) than the individualist group.

The fifth highest difference between both cultures (4.0%) is with respect to Tailoring/Customization, for which the collectivist group (4.5%) expressed a higher preference than the individualist group (0.5%). The explanation for this cultural difference regarding Tailoring/Customization is the same as that for Reminder/Notification and Suggestion/Recommendation.

6.7.5 Summary of Findings

Figure 6.17 and Figure 6.18 show the graphic plots of the key features (from the most to the least important) that the collectivist and individualist cultures, respectively, care about. Among the collectivists, to increase the use of a PHA such as a fitness app, the five essential features designers should give priority in their app design include Reminder/Notification (28.4%), followed by Self-Monitoring (23.9%), Behavior Model (9.0%), Suggestion/Recommendation (7.5%) and Exercise Timer (6.0%). Among the individualists, the five essential features to be given priority include Self-Monitoring (47.1%), Behavior Model (8.5%), Goal-Setting (5.8%), Workout Plan/Routine (4.2%), Exercise Timer (4.2%). Overall, in a one-size-fits-all application, persuasive features such as Self-Monitoring, Behavior Model and Exercise Timer should be supported. The finding that Self-Monitoring is one of the two most requested features by both cultures (in S3d) replicates the quantitative finding that Goal-Setting/Self-Monitoring is the strongest determinant of the *intention to use* a PHA (in S3c). The replication confirms the view that Goal-Setting/Self-Monitoring is the cornerstone of many health applications [62], which every minimally viable PHA should support in the least [209].

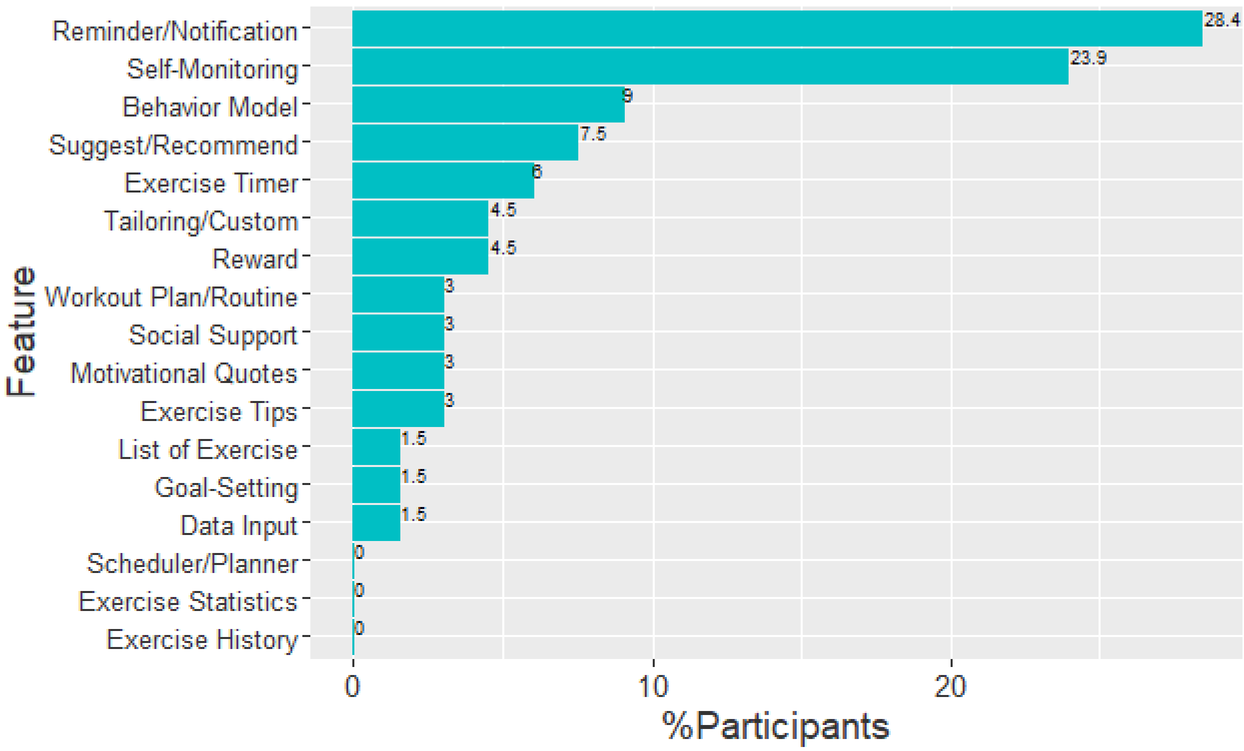

Figure 6.17: Key features of a PHA collectivist users care about (from most to least important)

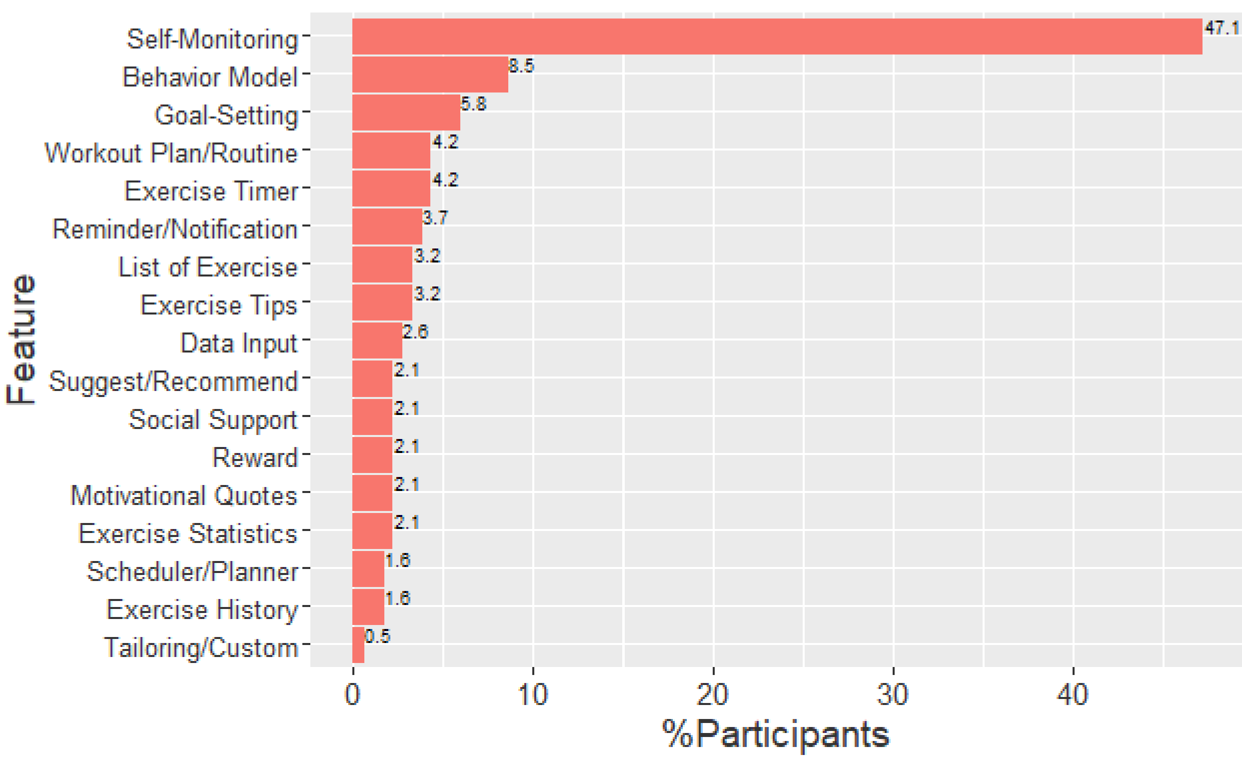

Figure 6.18: Key features of a PHA individualist users care about (from most to least important)

6.8 Summary of S3's Main Findings on Cultural Differences

For easy and quick access to the main findings of S3, I summarize the major cultural differences in the four investigations relating to PTAM and PTUM as follows:

1. In S3a and S3b, the individualist culture tends to care about *perceived usability* more than the collectivist culture. In contrast, the collectivist culture tends to care about *perceived usefulness* more than the individualist culture.

2. In S3a, *perceived persuasiveness* turns out to be a partial a mediator of the effect of *perceived usefulness* on *intention to use* in the individualist culture, but not in the collectivist culture.

3. In S3d, Goal-Setting and Self-Monitoring (self-initiated features) turn out to be more important to the individualist culture than to the collectivist culture. In contrast, Reminder/Notification and Suggestion/Recommendation (app-initiated features) turn out to be more important to the collectivist culture than to the individualist culture.

6.9 Conclusion

In this chapter, I presented the results of four mixed-method investigations on the PTAM and PTUM of the target audience and the moderating effect of culture. Specifically, I investigated the most important UX design attributes that influence the acceptance of a PHA using the PTAM. Secondly, I investigated the most important persuasive design features that influence the use of a PHA using the PTUM. Putting it together, the quantitative results on PTAM showed that, regardless of culture, *perceived aesthetics* and *perceived usefulness* are the most important UX design attributes that influence the *intention to use* a PHA aimed at motivating behavior change. The qualitative results confirmed the quantitative results, with *perceived aesthetics* being the most important perceived UX design attribute the target users care about, and *perceived usefulness* following in the second and third places for the collectivist and individualist cultures, respectively. Combined, both *perceived aesthetics* and *perceived usefulness*, which represent hedonic and utilitarian dimensions, respectively, can be regarded as the character of a persuasive system, which the designer employs to influence PHA acceptance [236]. In the context of PT, the character of a PHA summarizes its key attributes (hedonic and utilitarian) and "*provides support for anticipation, interpretation and interaction*" (p. 297) [270]. According to the theory of perception, people usually perceive things in their entirety, how their various components work together, and not what their individual components represent or do [261].

Secondly, the quantitative results on PTUM showed that, regardless of culture, Goal-Setting/Self-Monitoring is the most important persuasive design feature that influences the target users' *intention to use* a PHA aimed at motivating behavior change. The qualitative results confirmed the quantitative results, with Self-Monitoring being the most and second most important persuasive feature the individualist and collectivist users care about, respectively. Moreover, the qualitative results on PTUM showed that Behavior Model and Exercise Timer are among the three most important application features the target users, regardless of culture, care about. Hence, in my design of the PT intervention, I will ensure that the proposed PHA (fitness application) is well designed *aesthetically* and *functionally*. First, I will ensure that the UI of the app is highly aesthetic. Secondly, I will ensure the application is equipped with over 80% of the requested features in both cultures, including Goal-Setting/Self-Monitoring, Behavior Model, Exercise Timer, Reminder/Notification, Suggestion/Recommendation, Predefined List of Exercise, etc., to increase its *perceived* and *actual usefulness*.

6.10 Contributions

The main contribution of S3 is that it used a mixed-method approach that cut across both cultures to show that *perceived usefulness* and *perceived aesthetics* are the most important UX design attributes that drive the acceptance of a PHA. Specifically, it reveals the need for PT designers to strike a balance between the hedonic and utilitarian design of a PHA, which are manifested in its *perceived aesthetics* and *perceived usefulness*, respectively. Secondly, unlike prior TAM studies, through the mixed-method approach, I am able to establish, implicitly, a link between *perceived usefulness* in the PTAM (in the context of UX design) and the persuasive features in the PTUM (in the context of persuasive design). From the findings of S3, a *useful* persuasive system is the one that possesses essential features that help potential users achieve their health goals. From the thematic analysis of participants' comments, such a system is the one that *effectively* implements most of the key features requested by the study participants (see Table 6.22), including Goal-Setting/Self-Monitoring, Behavior Model, Reminder/Notification, Suggestion/Recommendation and Exercise Timer.

6.11 Limitations and Future Work

The Persuasive Technology Adoption Model study (S3) has a number of limitations. The first limitation is that it is based on the perception of the UX design attributes and persuasive features of a fitness application prototype rather than its actual usage. This limitation may threaten the generalization of the findings to an actual setting, in which participants used the application in a real-life setting. The second limitation of the study is that the sample sizes for the two cultures are not equal or balanced. The individualist culture (n = 189) had a larger sample size than the collectivist culture (n = 67). In the PTAM and PTUM investigations, this might have resulted in a higher chance of achieving statistical significance in the individualist models than in the collectivist models as a result of the larger sample size of the former. The third limitation is that, given that only one country (Nigeria) or two countries (Canada/United States) are used as a case study, the generalizability of the findings to other countries categorized as collectivist and individualist cannot be guaranteed. For example, the collectivist-based finding may not generalize to the Chinese population. The fourth limitation of the study is that it did not consider the effect of other key demographic factors such as gender, age, education, income, etc. Future research efforts can aim at addressing these limitations.

7 Design and Implementation of Culture-Tailored Persuasive Health Application

This chapter focuses on the fifth step of the EMVE-DeCK Framework, which is the design and implementation of an actual persuasive health application (PHA) aimed at promoting regular exercise behavior. The design and implementation of the PHA is situated in the EMVE-DeCK Framework as shown in Figure 7.1. Formally, this chapter sets out to answer the fourth research question of this dissertation (RQ4), "***How can we leverage the culture-specific empirical findings from the user studies in the design of an actual PHA tailored to the target audience?***"

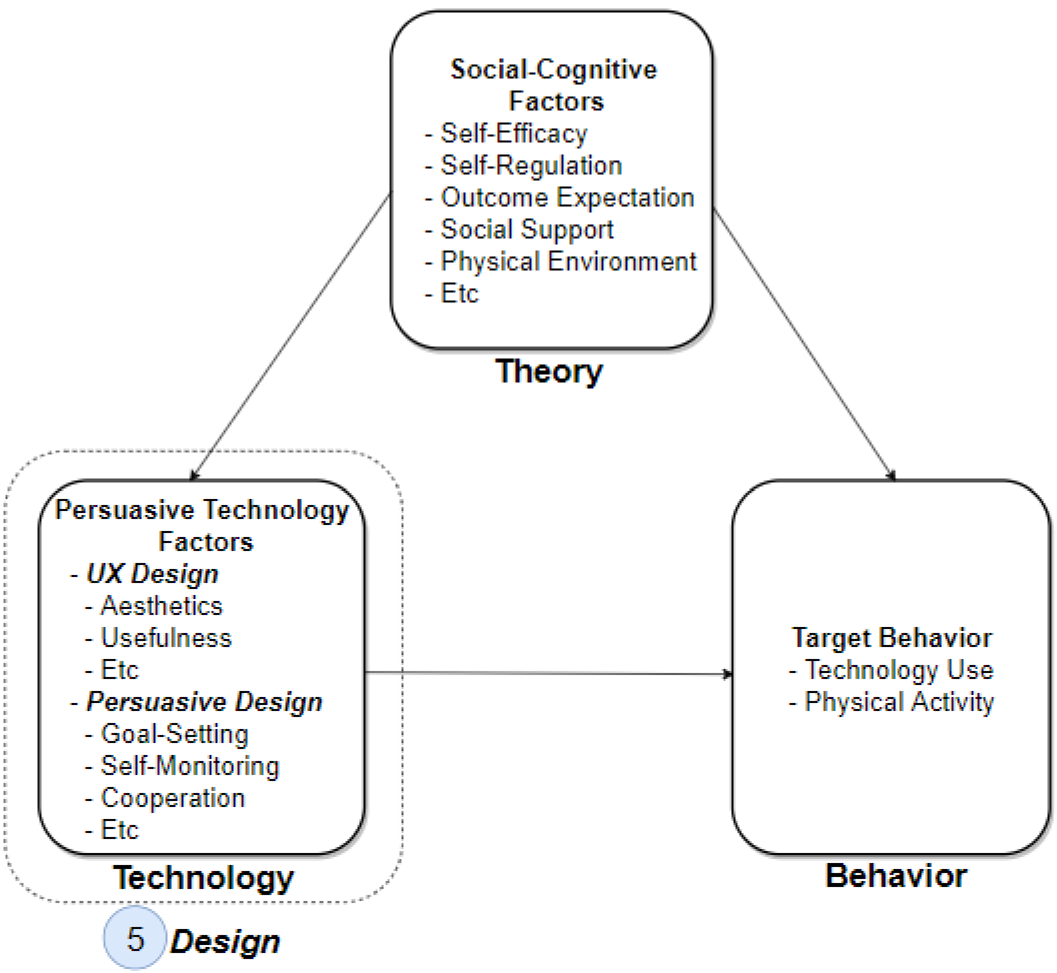

Figure 7.1: Situating the design and implementation of the PHA in the EMVE-DeCK Framework

In the preliminary user studies in the theory domain (S1) and technology domain (S2), I found that personal and social factors are more likely to motivate the physical activity of the individualist and collectivist cultures, respectively. Moreover, in S3, I uncovered the key features of a PHA the target users care about. As a result, based on these empirical findings, I designed and implemented two versions of a culture-tailored PHA (fitness app) called "BEN'FIT." The name "BEN'FIT" is deliberately chosen to allude to the act of exercising without the use of equipment (except the body itself used as a resistance) and its health benefits. This type of exercise is traditionally called calisthenics. Hence, the name "BEN'FIT" attempts to convey the overarching goal of the fitness app: "*. . .* ***ben****ding the body to become* ***fit!***" The two versions of the app include a personal version (PV) and a social version (SV) targeted at the individualist culture (Canadian/American population) and the collectivist culture (Nigerian population), respectively.

In this chapter, I discuss the development tools, architecture, design and implementation of the two versions of the BEN'FIT app (PV and SV), which were informed by the culture-specific findings from S1-S3. In addition to both versions of the BEN'FIT app, I discus the design and implementation of the control version (CV), which I called "EXLOGGER." The prefix "EX" denotes "Exercise," while "LOGGER" implies an electronic journal for keeping a record of exercises (activities). The EXLOGGER is the control version against which the intervention versions (PV and SV) are compared. The comparison is aimed to evaluate the effectiveness of the persuasive health intervention in motivating physical-activity behavior change.

7.1 Development Tools for BEN'FIT

A number of tools were used to develop the BEN'FIT app. First and foremost, the app was developed using Android Studio [80], which is an integrated development environment (IDE) for developing Android-based mobile applications. Android Studio is built on JetBrains' IntelliJ IDEA software. Specifically, I used Android Studio 3.4 to develop the BEN'FIT app. Second, I used GitHub, in collaboration with research assistants, as a version control management system for the development of the app. GitHub is a web-based hosting service, which is based on Git and owned by Microsoft. It is used by developers for collaboration, version control, review and management of source code [81]. Third, I used Google Firebase (Figure 7.2), a mobile and web application development platform that provides developers with a number of cloud-based tools and services to help them develop high-quality apps easily [82]. Some of the main services provided by Google Firebase, which I used in the development of the BEN'FIT app, include Authentication, Database, Cloud Messaging, Functions, Storage, Notifications, Crash Reporting, etc., which are briefly discussed in the next section. Fourth, Google Fit Application Programming Interfaces (APIs, e.g., Recording and History APIs) were used as cloud-based services to automatically track the users' step counts. Google Fit is an open-source platform that allow developers to build health apps and users to control their health and fitness data [83]. Finally, Google Console Play [84] was used to host the different versions of the app and invite pre-pilot testers and study participants to test and pilot the app, respectively. Shown on the left-corner and at the center of

Figure 7.3 are some of the main features of the Google Play Console and the account detail of the developer, respectively. Some of the main features of the console include applications, managing email list, activity log, API access, etc., most of which are employed in the development and evaluation of the app.

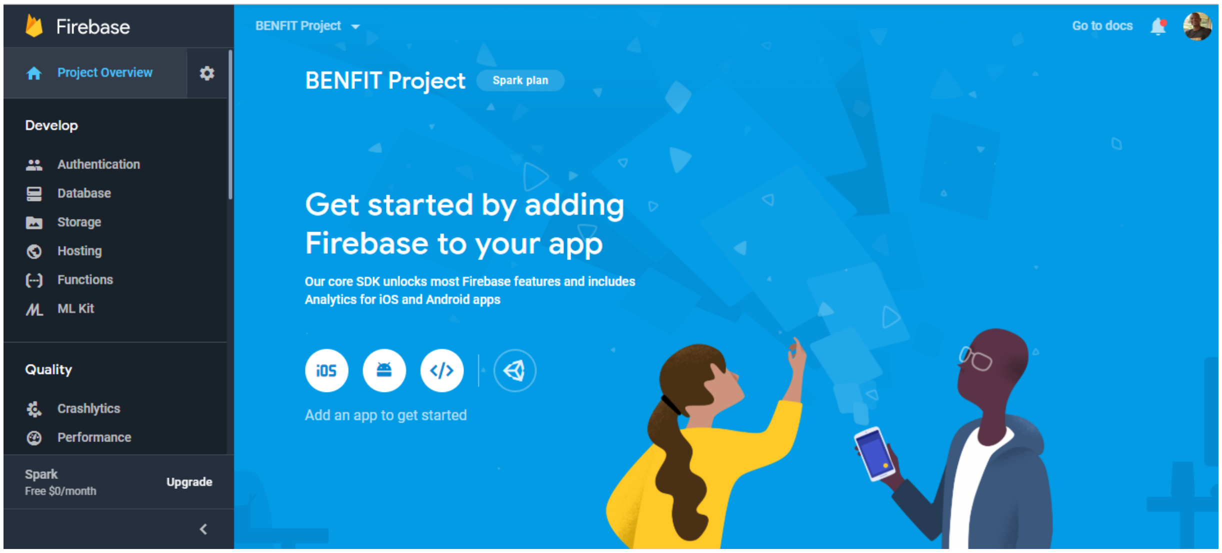

Figure 7.2: A screenshot of Firebase main interface showing some of its functionalities

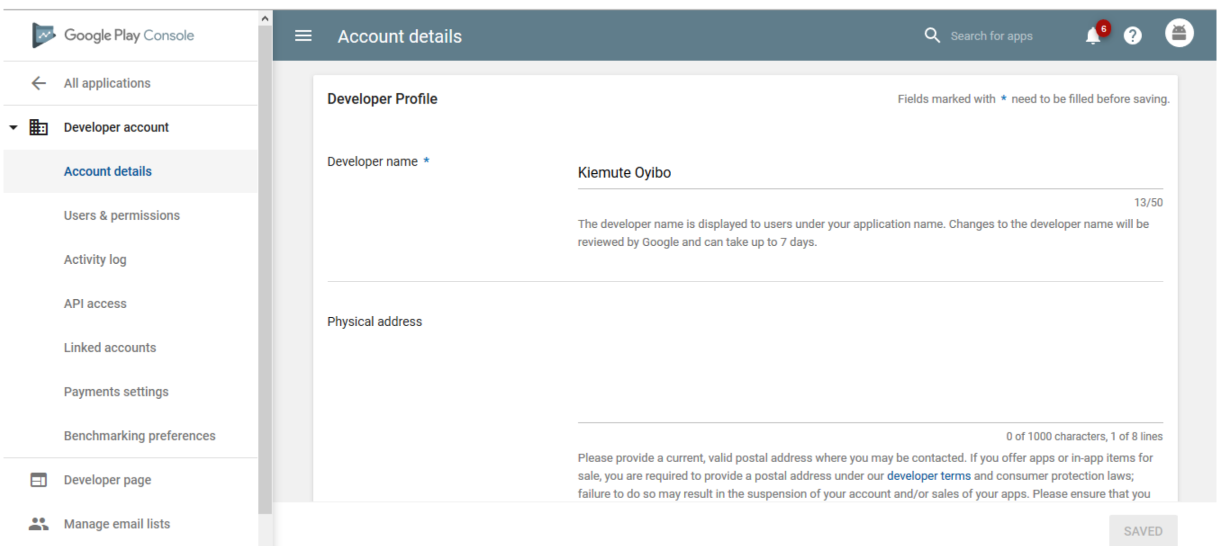

Figure 7.3: A screenshot of Google Play's main interface showing some of its functionalities

7.2 Architecture of BEN'FIT

The BEN'FIT app leverages the state-of-the-art cloud-based services to realize its functionalities. Shown in Figure 7.4 is the architecture of the BEN'FIT app, which depicts the interaction among its various cloud-based components and the mobile client in which it is deployed.

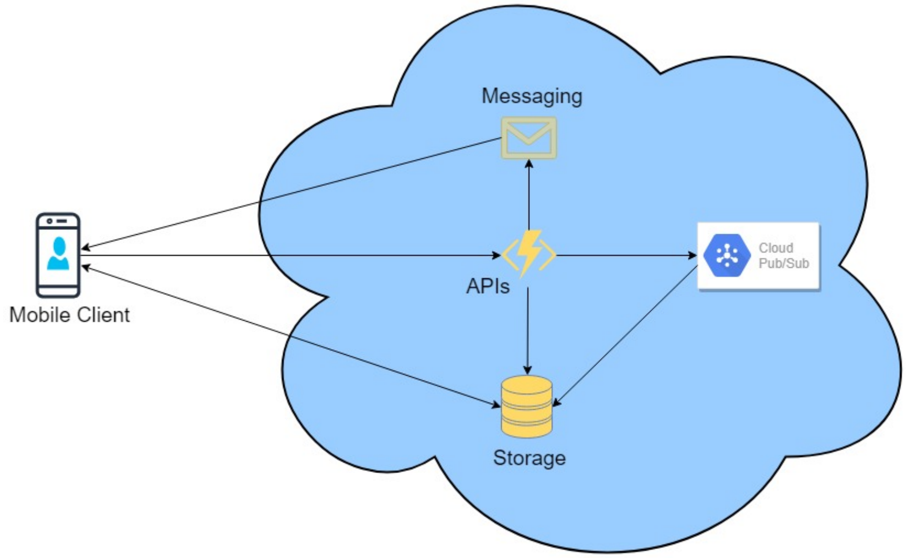

Figure 7.4: Architecture of the BEN'FIT app

Mobile Client This is the mobile device in which the BEN'FIT app is installed and run by the user. To download and sign up to the use the app, users are expected to use their Gmail account as a way of authenticating them. For this reason, only accounts (Gmail addresses) that have been invited to use the app can download it from Google Play and install it on their smartphone. These users' Gmail accounts are stored in a database of users (testers) in the Google Play Console. Figure 7.5 shows a screenshot of the Google Play Console, which displays a preliminary number of users invited to test/evaluate each version of the app.

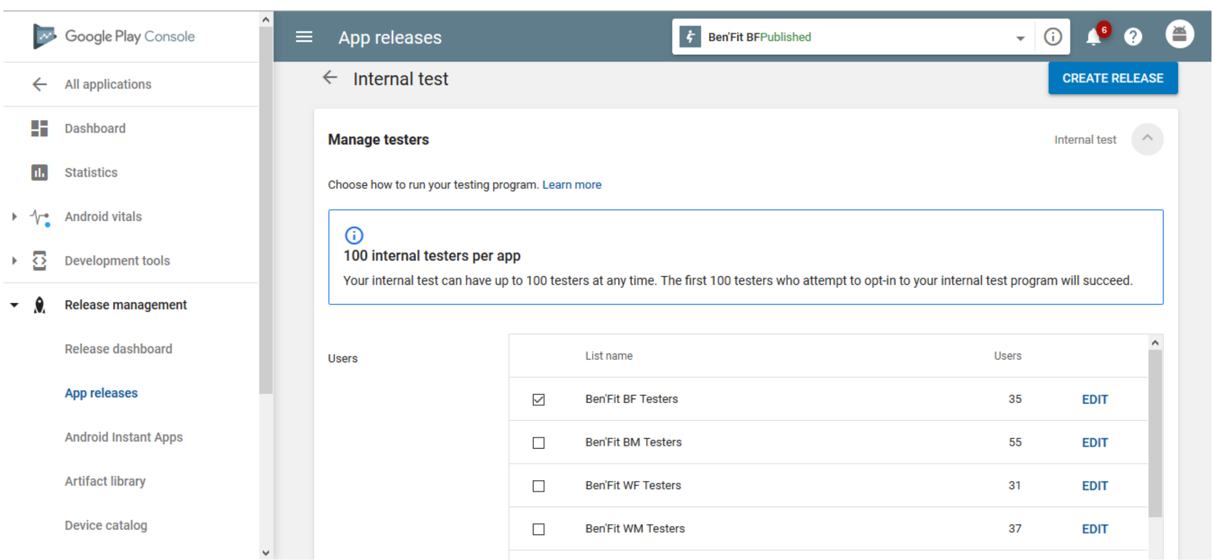

Figure 7.5: Google Play Console showing the number of users invited to test the BEN'FIT app

Overall, four groups of users were invited to evaluate the intervention app, which is tailored to each group in terms of the race and gender of the behavior models featured in the app. The four groups, which correspond to the four versions of the behavior models, include black male (BM), black female (BF), white male (WM) and white female (WF). In total, excluding unofficial testers (e.g., research assistants, etc.), about 150 users were invited to test/evaluate the BEN'FIT app. Overall, excluding pre-pilot testers, 34 black females, 52 black males, 31 white females and 36 white males were invited to use the intervention app. However, only a fraction of these numbers actually downloaded, installed the app and participated in the pilot study

Cloud Messaging The messaging component is used to send notification messages to the mobile client. These notification messages can be directed to a certain user, group of users or all of the users of the BEN'FIT app. Figure 7.6 shows some of the notification messages sent to users of the BEN'FIT app, one of which is, "*To chat with your partner, use the chat app in menu or top-right corner of the home interface.*" The cloud messaging system allows users in social settings to communicate with one another using an in-built chat app.

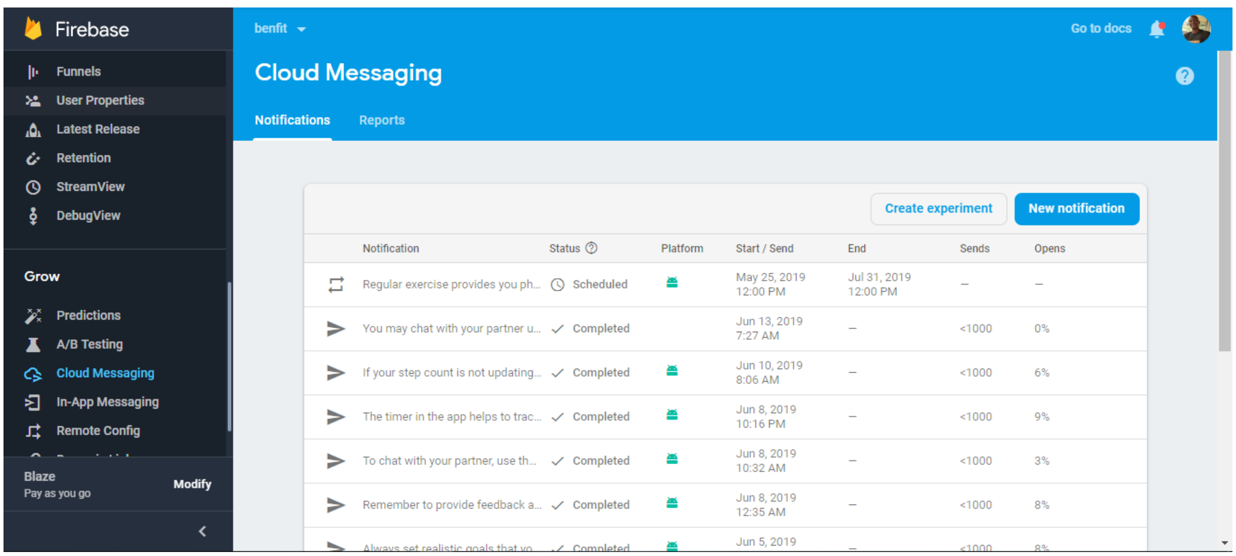

Figure 7.6: Google Firebase showing a number of notifications sent to users of the BEN'FIT app

APIs/Cloud Functions The APIs/Cloud Functions component represents backend codes stored in the cloud, which are triggered in response to HyperText Transfer Protocol (HTTP) requests. This component makes it easy to update the app using the cloud-based backend code without releasing a new version of the app. It also makes it easy to integrate with other cloud functionalities such as messaging, storage and Cloud Pub/Sub services. Figure 7.7 shows some of the cloud functions used in the BEN'FIT app, which include `editGoal()`, `resetGoal()`, `createGroupByAdmin()`, `joinGroup()`, etc. For example, the `resetGoal()` function allows the app to reset users' goals automatically on a weekly basis, i.e., at the end of each of each week throughout the pilot study period. Similarly, the `joinGroup()` function allows the researchers, with the aid of an admin app, to assign two participants, who are assigned to use the SV version of the app, to a given group.

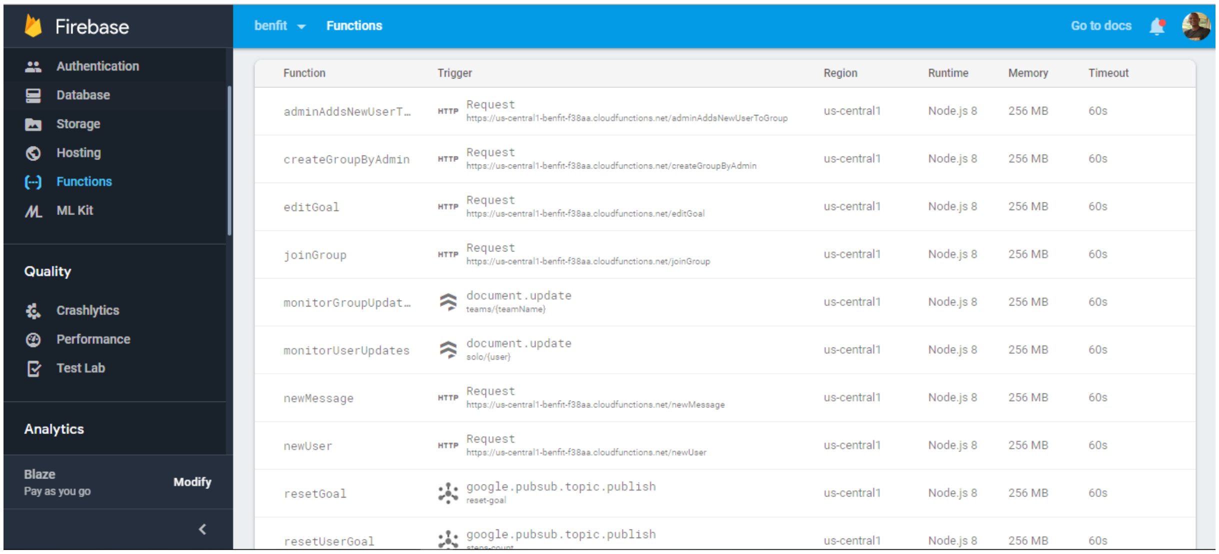

Figure 7.7: Google Firebase showing a number of cloud functions used in the BEN'FIT app

Database. The cloud-based database component is a flexible and scalable database that is used to store user data (e.g., demographic data, calories burned, step count, etc.) in the cloud. It allows user data to be pushed and retrieved from the cloud through Internet connection. It keeps user data in sync and supports offline capability as well. Basically, user data is stored as JSON objects in a tree format in the database. Figure 7.8 shows the database collections used in the app, which include "activity_list," "control-group," "feedback," "previous-goals," "solo," "teams" (i.e., "groups") etc. Highlighted is the collection "solo," which indicates a collection of users using the PV version of the app. It comprises a number of documents (user ids), with each document comprising nested collections (such as "activities" and "step_count" of the user) and user-specific fields (such as "PAL Done," "PALValue," "activities," "calories," "country," "currentWeek," etc.).

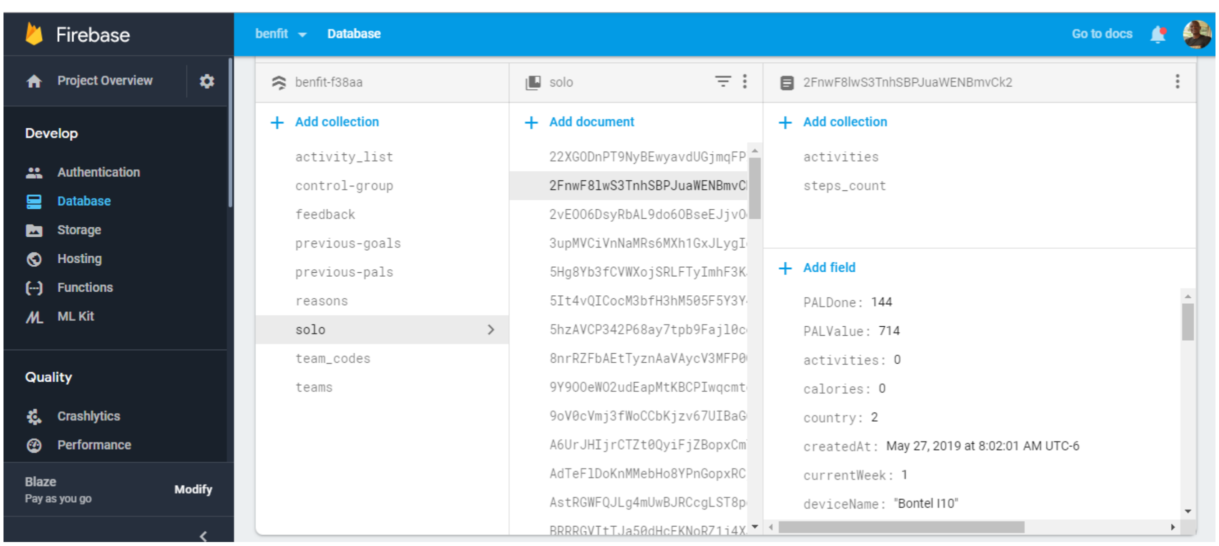

Figure 7.8: Google Firebase showing the database collections at the backend of the BEN'FIT app

Cloud Pub/Sub. The Cloud Pub/Sub component is used to schedule cron (time-based) jobs, which automatically activate after a specified period of time. For example, for each participant in the pilot study, the app automatically resets the user's goal on a weekly basis at a certain time and day of the week.

7.3 Overview of the Key Features of BEN'FIT (PV and SV) and EXLOGGER (CV)

Each of the three versions of the PHA is equipped with a number of key features to motivate and facilitate physical-activity behavior change. In particular, the features of the PV and SV versions were informed by the culture-specific empirical findings in Chapters 4 and 5. Table 7.1 shows the supported features (persuasive and supportive) in each of the three versions of the PHA. All of the three versions have a number of common features, which include Self-Monitoring, Exercise Timer, Exercise Data Input, Step Counter and Exercise History. Particularly, the PV and SV versions have a number of exclusive features such as Goal-Setting, Reminder/Notification, Behavior Model, Reward, Predefined List of Exercise, Exercise Tips, etc.

Table 7.1: Persuasive and supportive features implemented in each version of the PHA. "✓" = supported features, "×" = unsupported features, "*" = other supportive features implemented in the health application (though not explicitly requested by the study participants).

No.	Key Feature	PV	SV	CV
1	Self-Monitoring	✓	✓	✓
2	Reminder/Notification	✓	✓	×
3	Behavior Model	✓	✓	×
4	Exercise Timer	✓	✓	✓
5	Goal-Setting	✓	✓	×
6	Workout Plan/Routine	×	×	×
7	Suggestion/Recommendation	✓	✓	×
8	Exercise Tips	✓	✓	×
9	List of Exercise	✓	✓	×
10	Reward	✓	✓	×
11	Cooperation	×	✓	×
12	Social Learning	×	✓	×
13	Social Comparison	×	✓	×
14	Chat App/Forum	×	✓	×
15	Calorie Data Input	×	×	×
16	Exercise Data Input	✓	✓	✓
17	Step Counter	✓	✓	✓
18	Motivational Quotes	✓	✓	×
19	Summary Statistics	✓	✓	×
20	Tailoring/Customization	✓	✓	×
21	Scheduler/Planner	✓	✓	×
22	Exercise History	✓	✓	✓
23	Help*	✓	✓	✓
24	Health Information*	✓	✓	✓

The BEN'FIT app, for example, the SV version, is equipped with over 85% of the key features requested by the collectivist participants in S2/S3. Similarly, the PV version, excluding the social features that individualist users are unlikely to be receptive to, is equipped with over 85% of the key features requested by the individualist participants in S2/S3 as well. The key personal persuasive features the PV version is equipped with include Goal-Setting, Self-Monitoring, Reward, Behavior Model (race-and-gender-tailored), Reminder/Notification and Suggestion/Recommendation. In addition to these PV features, the SV version is equipped with Cooperation, Social Learning and Social Comparison and Chat App, which enables peers to communicate with one another. In particular, Goal-Setting and Reward were implemented in the SV version in a social setting. However, the CV version is only equipped with Self-Monitoring (among all of the persuasive features in PV and SV) in its very basic form: users being able to log and view their exercise data, including step count, at a later date.

Finally, in addition to categorically requested features by the study participants, all three versions of the PHA are equipped with Help and Health Information. The former provides essential information about the app, while the latter provides basic health information from health organizations such as World Health Organization (WHO). Users might need this information to support and motivate their physical activity.

7.4 Overview of the Interface and Persuasive Design of BEN'FIT

In this section, I provide an overview of the two versions of the BEN'FIT app (PV and SV) by focusing on the persuasive and supportive features employed in the design of their homepage and other pages.

7.4.1 Description of Main Menu of BEN'FIT

In this section, I discuss the functionalities of the BEN'FIT app common to both PV and SV. Overall, the BEN'FIT app comprises 10 main functionalities (excluding credits) as shown in the main menu of the app in Figure 7.9. I provide an overview of each of the menu items (functionalities) in the following subsections.

Home Interface. This is the main user interface (more or less a dashboard) that allows users to set weekly goal and monitor their performance and progress over time. It helps users to keep track of their physical activity level (PAL), the week users are in, the reward (points and medals) earned so far, step count, and the numbers of activities performed. Moreover, it allows users to edit their goal whenever necessary.

Collaborate Interface. This user interface enables users to join a predefined group (created by the researcher) with the aid of a group code given to designated users by the researcher.

Account Interface. This user interface displays the user's demographic information, e.g., `weight (kg)`, `height (cm)`, `body-mass-index(BMI,` kg/m^2`)`, `gender`, `age` and `country`. This information is subject to editing by the user.

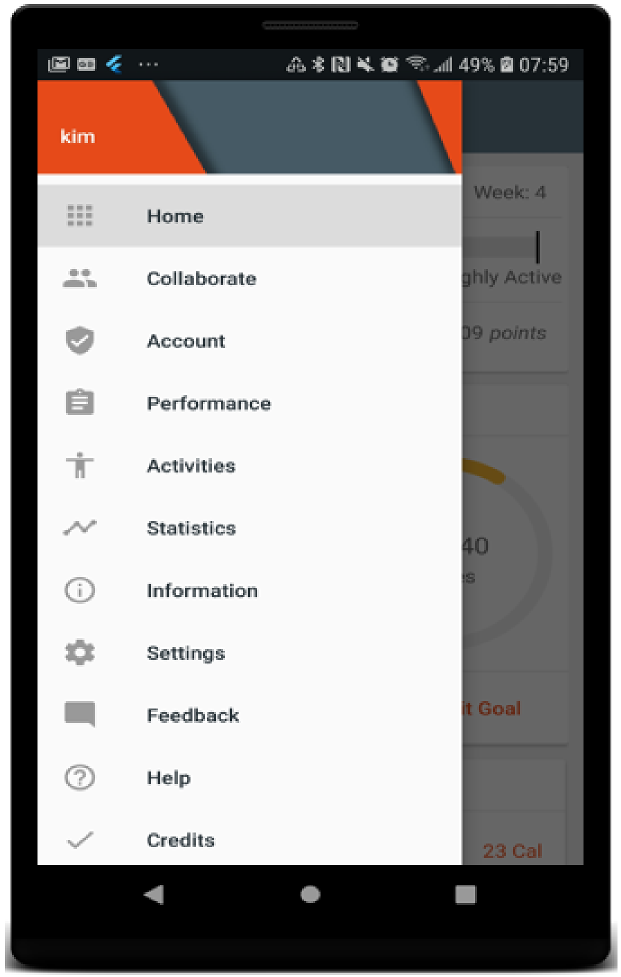

Figure 7.9: Functionalities of the BEN'FIT App

Performance Interface. This user interface allows users to view their weekly performance (current and previous) in the light of their weekly goals. The displayed performance metrics include step count, calories burned, number of activities done and percentage of user's goal achieved.

Activities Interface. This user interface offers 12 types of activities (bodyweight exercises). They include push-up, push-up and rotation, squat, chair dip, crunch, plank, side plank, jumping jack, wall sit, step up, lunge, running in place (see Figure C.1 in Appendix C). Each of the 12 types of exercise is represented by a thumbnail of its corresponding behavior model. Users can select one of the 12 activities that they wish to perform. When an activity is clicked, the behavior-model video opens. In this interface, there is a timer beneath the behavior-model video that users can use to track the duration of their activities and the calories burned. Moreover, users can pause the timer to take a rest or break from their workout and resume later.

Statistics Interface. This user interface allows users to visualize the summary statistics of their activities such as total step count, calories burned, minutes worked out, etc.

Information Interface. This user interface contains some basic health information users may need to know, e.g., benefits of exercise, types of exercise, BMI, WHO's recommendation, etc.

Settings. This user interface allows users to activate and deactivate the reminder functionality. It also allows them to set commitment days and times at which the app will remind them to exercise.

Feedback Interface. This is a user interface that allows users to provide feedback to the researchers, for example, how they feel upon completing their workout session on a given day, what their challenges are if any, the reason they could not engage in exercise on a given commitment day, etc.

Help Interface. This user interface contains help information. Basically, it contains explanation of the various functionalities and persuasive features of the fitness app such as, Home, Account, Feedback, Chat, Reward, etc. Credit Interface. This is a user interface (page) in which credit is given to the authors/designers of the third-party resources (e.g., medal, trophy icons) used in the development of the app.

7.4.2 Homepage Design of BEN'FIT PV Version

Figure 7.10 shows the homepage of the PV version of the BEN'FIT app, which is equipped with three personal persuasive features: Goal-Setting, Self-Monitoring and Reward. Basically, the user interface is composed of four sections: the Physical Activity Level (PAL) section, the reward section, the weekly goal section and the activities section. Overall, the home interface, enables the users to track/monitor their personal informatics in relation to their physical activity. The metrics measured include PAL, medal/points earned, step count, number of activities engaged in, overall calories burned and calories burned per activity.

PV Physical Activity Level (PAL) Section

The first section of the app is the user's PAL visualization, which enables users to track/monitor their PAL over a week period. It shows a progress bar, which is used to visualize the PAL of the user over a week period. The progress bar ranges from "Inactive" to "Highly Active" level. In between is the "Active" level. These levels are based on the WHO's physical activity level guidelines: moderate level (600 MET-mins) and high level (3500 MET-mins). Based on the WHO's guidelines, the moderate level of physical activity is the minimum amount of MET-mins required for a person to be active over a week period. However, the metric "MET-mins" is presented in terms of "calories," which users can easily relate with and is dependent on the user's weight. It is noteworthy that, in the health domain, just as in the BEN'FIT app, 1 kilocalories is simply referred to as 1 calorie (1 Cal) for brevity. So, for a person of average weight 80 kg, the minimum calories s/he is expected to burn over a week period to be active (840 calories) can be calculated using Equation 7.1. Based on WHO's recommended weekly PAL of 600 MET-mins/week for a person to be active and substituting the weight variable, we have: $Calories/week = 600MET - mins \times 3.5 \times 80kg/200 = 840calories/week$.

$$Calories/week = \frac{MET \times Time(mins) \times 3.5 \times Weight(kg)}{200} \tag{7.1}$$

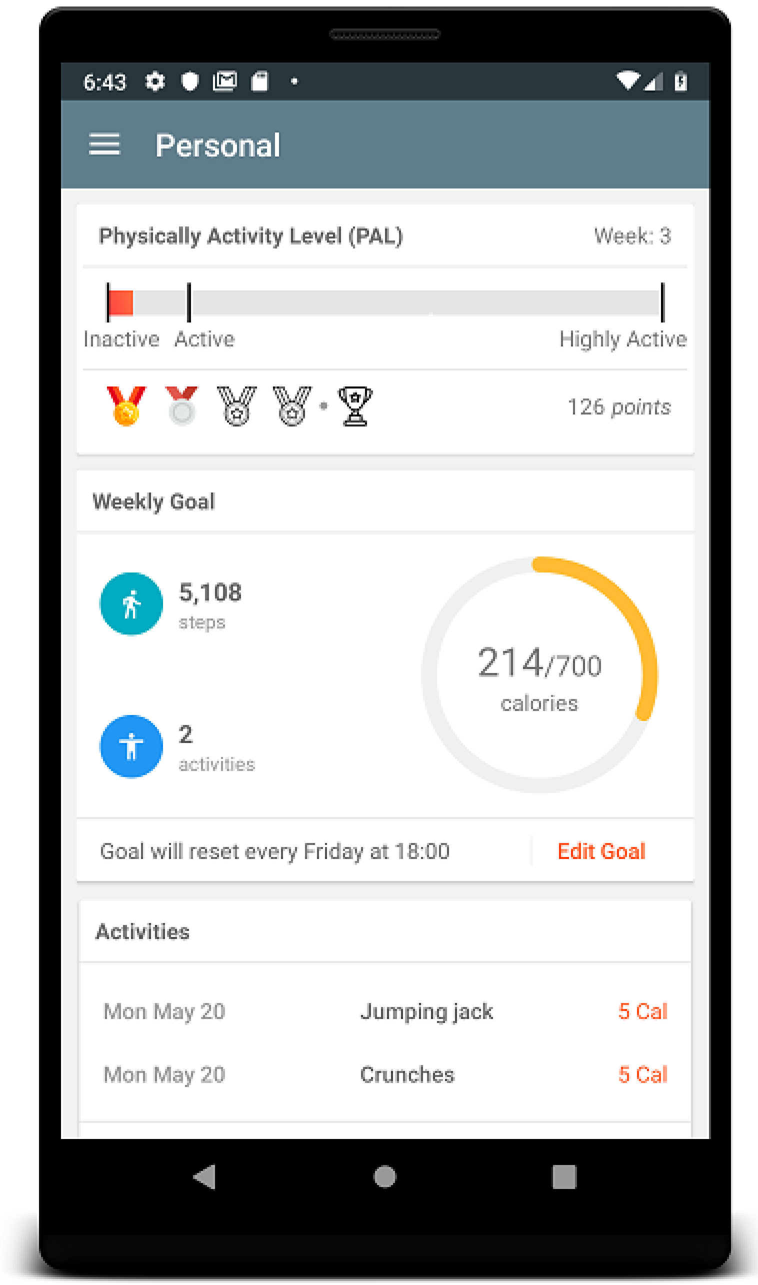

Figure 7.10: UX/persuasive design of the PV version of the BEN'FIT app

PV Reward Section

The second section of the app is the Reward feature. The feature enables users to be rewarded with points and medals for the accomplishment of their goals.

Points Based on Activities (Implemented at the Personal Level). If a user is able to burn up to X calories while exercising, s/he earns x^2 points. However, the user is expected to burn up to 5 cals before s/he can start earning points. This is implemented this way so as to encourage the user to engage in an activity for a long time, at least for 1 min, which is equivalent to about 5 cals for an average person of 80 kg. In that case, it is better to do 2 mins at a stretch to earn, say, $(10^2) = 100$ points compared with doing two 1 min's to earn $(5^2) \times 2 = 50$ points, 25 points each. Overall, the reward computation algorithm is aimed at reflecting the research finding that people benefit more if they engage in exercise for a longer period of time. Moreover, given that the app is aimed at encouraging home-based exercises rather than walking, more weight is given to the former than the latter in calculating the points.

Points Based on Step Counts (Implemented at the Personal Level). For walking, if a user reaches x step counts, s/he gets $(x/100)$ points. However, a user is expected to hit 100 points before s/he starts earning points. For example, if a user hits 100 step counts, s/he gets $(100/100) = 1$ points; if a user hits 200 step counts, s/he gets $(200/100) = 2$ points; and so on and so forth. Moreover, for every multiple of 5000 steps achieved by the user, s/he is awarded $(x/1000)^2$, where x is a multiple of 5000. For example, if a user hits 5000 steps, s/he earns $(5000/1000)^2 = 25$ points as bonus. Moreover, if a user hits 10000 steps, s/he earns $(10000/1000)^2 = 100$ points as bonus. And so on and so forth.

Overall Points Based on Activities and Step Counts (Implemented at the Personal Level). The overall user's point (shown in the reward (second) section of the homepage) is calculated as a sum of the points earned for performing activities and walking.

Medal. A gold medal is awarded to the users for achieving their weekly goal. Otherwise, a silver medal is awarded for being active at least. Thus, four medals are awarded to the users for being active or meeting their goal for a four-week period. In addition, a gold trophy is awarded to the users if their cumulative points (earned over time) reach a certain threshold (20000 points) at the end of the four-week period.

PV Weekly Goal Section

The third section of the BEN'FIT app is the Goal-Setting/Self-Monitoring feature. The feature helps users to edit their weekly goal and keep track of their bodyweight exercises (number of activities), step count and calories burned over time. Upon clicking on "Edit," the Goal-Setting user interface opens up. This interface enables users to set their weekly goal. The app stipulates a minimum level of calories to be burned for the user to be (moderately) active and highly active, which is based on the WHO's guidelines. For example, for a person of average weight (80 kg), the calories s/he is expected to burn to be active and highly active is 840 Cal and 4900 Cal, respectively. Moreover, as shown in the bottom-left corner of the Goal-Setting/Self-Monitoring section, the goal, step count and #activities are automatically reset on a weekly basis.

PV User Activities Section

The fourth section of the app shows a list of the activities a user engaged in, the date each activity is performed and the calories burned for each activity. To see more of these activities over time (i.e., the history of activities), the user can click on "See all activities," which is not visible in Figure 7.10.

7.4.3 Homepage Design of BEN'FIT SV Version

Figure 7.11 shows the homepage of the SV version of the BEN'FIT app. It is equipped with three social persuasive features (Cooperation, Social Learning and Social Comparison) in addition to the three personal persuasive features (Goal-Setting, Self-Monitoring and Reward), which are implemented on a group basis. Just like the PV version, the user interface of the SV version is composed of four sections: the Physical Activity Level (PAL) section, the reward section, the weekly goal section and the member's contribution section.

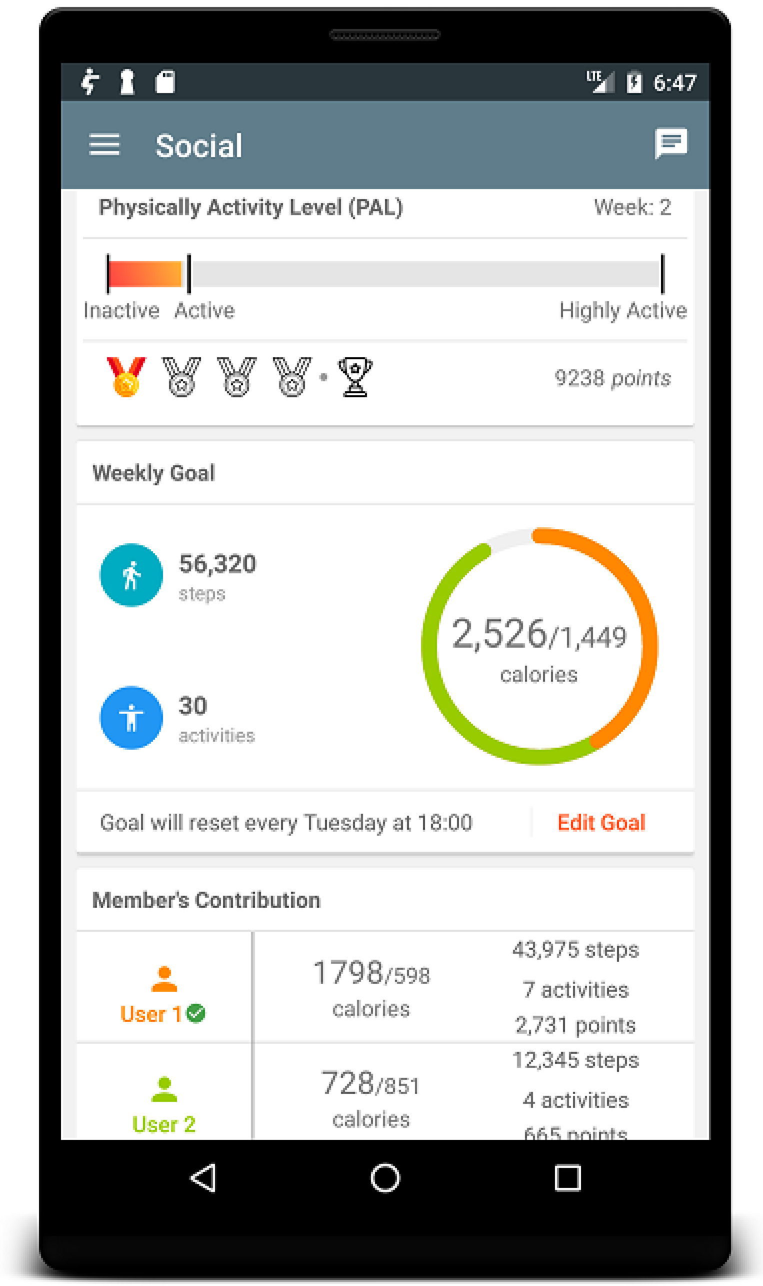

Figure 7.11: UX/persuasive design of the SV version of the BEN'FIT app

SV Physical Activity Level (PAL) Section

The first section of the SV version of the app, just like that of the PV version, shows a progress bar for tracking the physical activity level of the user at the individual level. Though this progress bar is contained in the SV version of the app, it is implemented at the individual level and not at the group level. This means a user can be said to be active at an individual level even though the other members of the user's group are not active. This enables individual users to monitor their activity level even though the other partner is falling short in terms of the achievement of the collective goal to which the reward is tied.

SV Reward Section

The second section of the SV versions of the apps shows the Reward feature, which is implemented on a group basis. This means users in the same group are rewarded if they meet their individual goals, which translate into meeting their collective goal, which is the sum of their individual goals. For example, if they are two users in a group, with one having a weekly goal of 800 cals and the other 1000 cals, to reach their collective goal, both of them need to burn up to 1800 cals (with each of them achieving their weekly goals) to earn a gold medal over a week period. Moreover, for the two-user group to earn the gold trophy at the end of the four-week period, both users need to earn up to 40000 points collectively.

SV Weekly Goal Section

The third section of the SV version is the Goal-Setting/Self-Monitoring feature, which is implemented on a group basis. Specifically, this feature helps the users in a given group to edit their weekly goal individually. However, the individual weekly goals are summed up to arrived at the collective goal displayed on the right hand side of the ring. Thus, collectively, users in a group are able to keep track of their attainment of their collective weekly goal. In addition, they are able to monitor their collective step counts and number of activities (#activities) engaged in over a week period. Just like in the PV version, as shown in the lower part of the weekly goal section ("*Goal will reset every Monday at 18:00*"), the collective goal, collective step count and collective #activities are reset on a weekly basis for both users in the group.

SV Member's Contribution Section

Finally, the last section of the app keeps track of each group member's individual weekly goal (in calories), number of activities, step count, and overall calories burned (for all weekly activities and step count). Clicking on "See all activities" on the bottom part of the screen (which is not visible) will display the Activity History user interface. The Activity History shows a list of the activities both members of the group engaged in, the date they engaged in them and the calories burned for each activity.

7.4.4 Implemented Key Features of BEN'FIT

In this section, I discuss the key features of BEN'FIT, which are implemented to support and motivate physical activity. The features are common to the PV and SV versions of the app.

Goal-Setting and Suggestion/Recommendation. This persuasive feature allows users to set their weekly goal. A default weight-dependent weekly goal (600 MET-mins based on WHO's guideline) is preset for the user. For example, as shown in Figure 7.12, the user who weighs 80 kg is recommended 840 cals/week to be (moderately) active. Alternatively, if the user's goal is to lose weight, then s/he is recommended a minimum of 3500 cals/week to lose a pound. To prevent users from setting simplistic goals (e.g., 5 cals/week), they are not allowed to set a weekly goal that is less than the minimum guideline recommended by WHO.

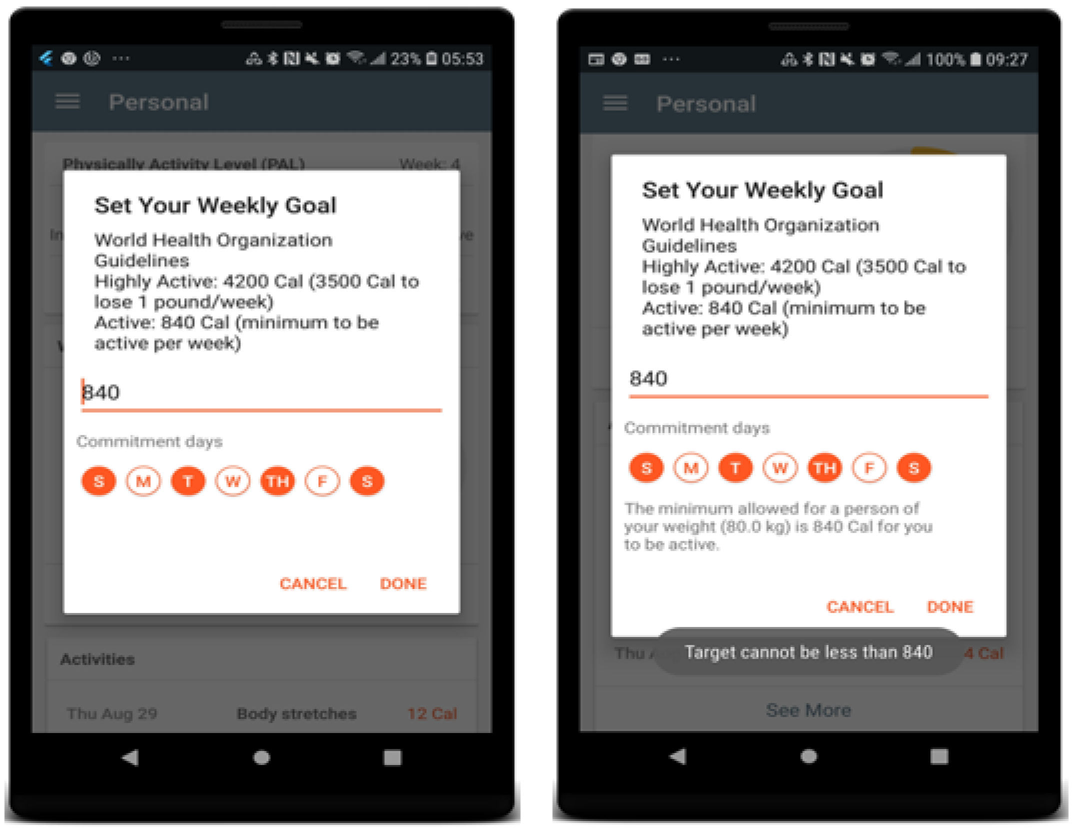

Figure 7.12: Goal-setting and suggestion/recommendation feature

Scheduler/Planner and Reminder. These features help the user to set commitment days, specific time to exercise and reminders. For example, with the aid of Scheduler/Planner (Figure 7.13), the user sets every other day of the week at 6.30 am to exercise. A notification is sent to the user on the preset days and time to remind him/her to exercise. The implemented Scheduler/Planner is basic. Hence, while users can schedule the days and times for their workouts for the week and set reminders, they cannot specify the types of exercise they wish to engage in, and the number of sets and reps as in a standard workout plan.

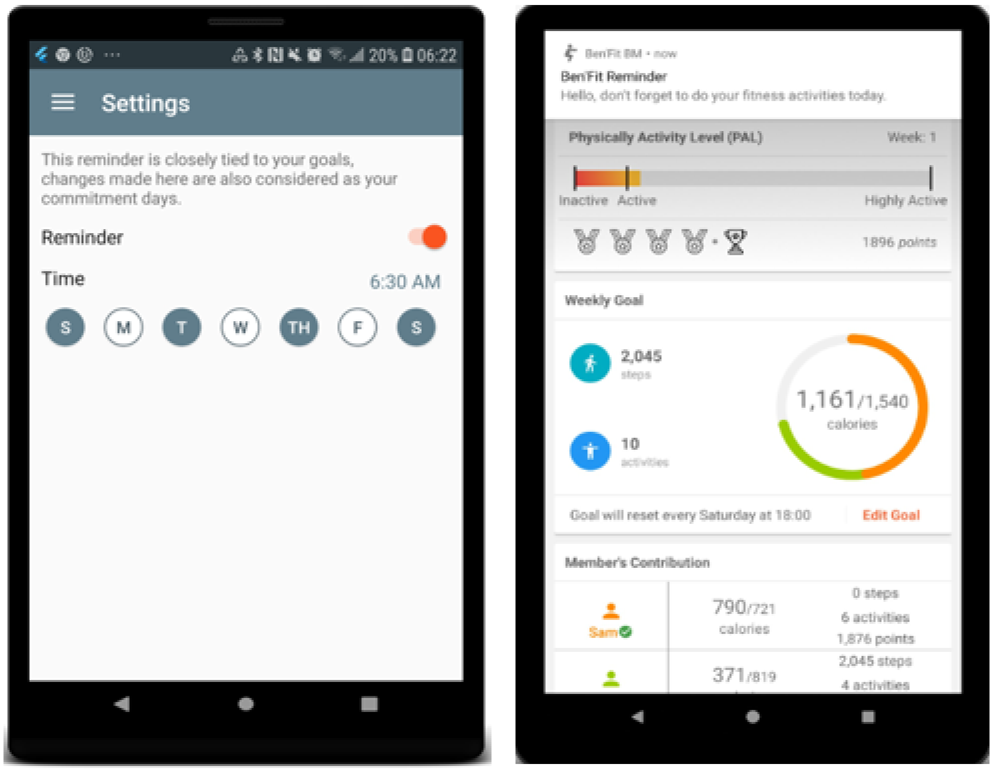

Figure 7.13: Scheduler/Planner and Reminder features

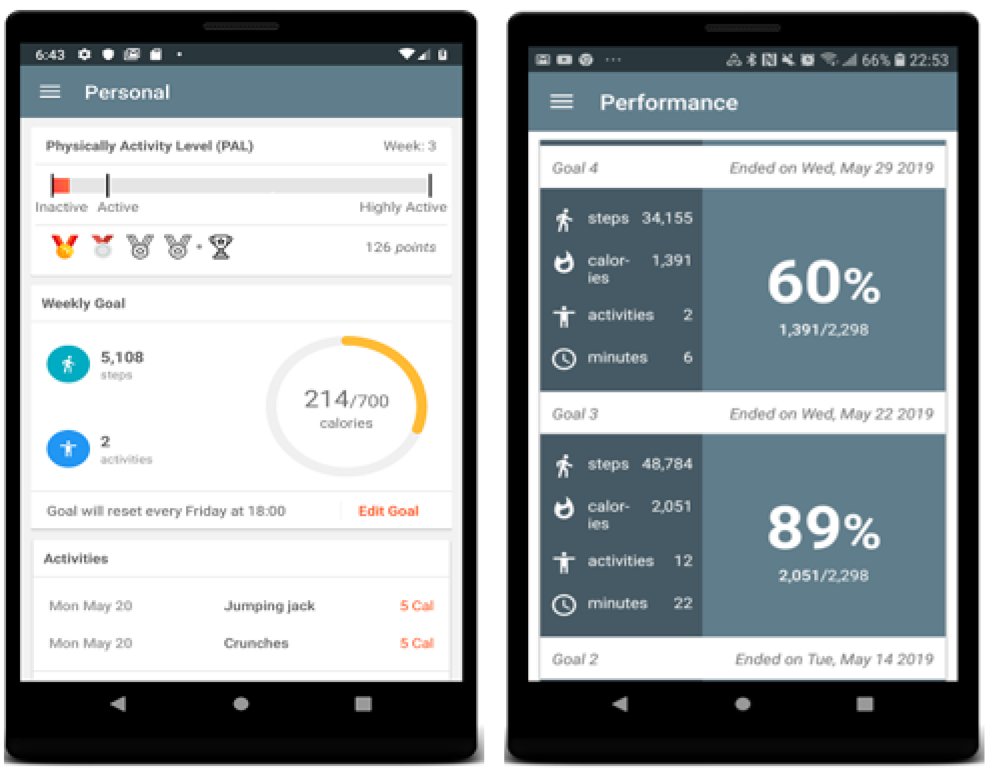

Figure 7.14: Self-Monitoring feature

Self-Monitoring. Self-Monitoring is implemented in various parts of the app, including the homepage (Figure 7.14). In this interface, there is a progress bar (tracking the user's current PAL/week), a ring (tracking the current calories burned), the step counter (tracking the current number of steps taken) and the activities tracker (tracking the current number of exercises done). Other implementations of the Self-Monitoring feature include the History page, Statistics page and Performance page (right-hand side of Figure 7.14), which shows the user's weekly goals and the percentages that were achieved. For example, in the third week (Goal 3), the user achieved 89% of his/her goal, while in the fourth week (Goal 4), s/he achieved 60%.

List of Exercise. This user interface features a list of 12 bodyweight exercises (see Figure C.1), from which a user can choose. Figure 7.15 shows two layouts of the 12 exercises (list and grid), e.g., Plank, Push Up, Squat, etc. On clicking on each thumbnail, the full video of the corresponding behavior model opens up.

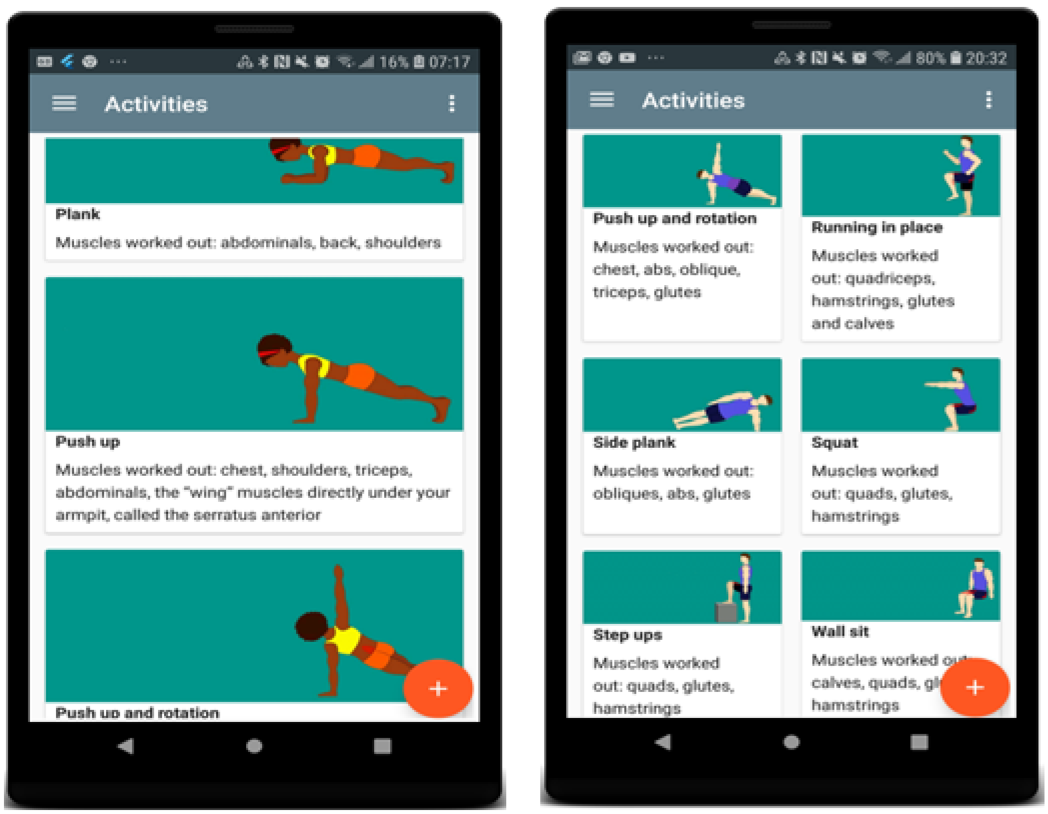

Figure 7.15: List of Exercise feature

Behavior Model/Exercise Timer. This user interface (Figure 7.16) features a video of each of the 12 race- and gender-tailored behavior models, demonstrating to the users how an exercise can be correctly performed. Each exercise behavior is modeled visually and textually. The body movement of the behavior model is synced with the instructions. In addition, this interface hosts a timer which allows the users to time their exercise while they watch the behavior model perform the exercise. The users can pause the timer anytime to rest and continue later. See Figure C.2 for a full-blown snapshot of a black male performing chair dip and Figure C.3 and Figure C.4 for the code snippet implementing the behavior model and exercise timer.

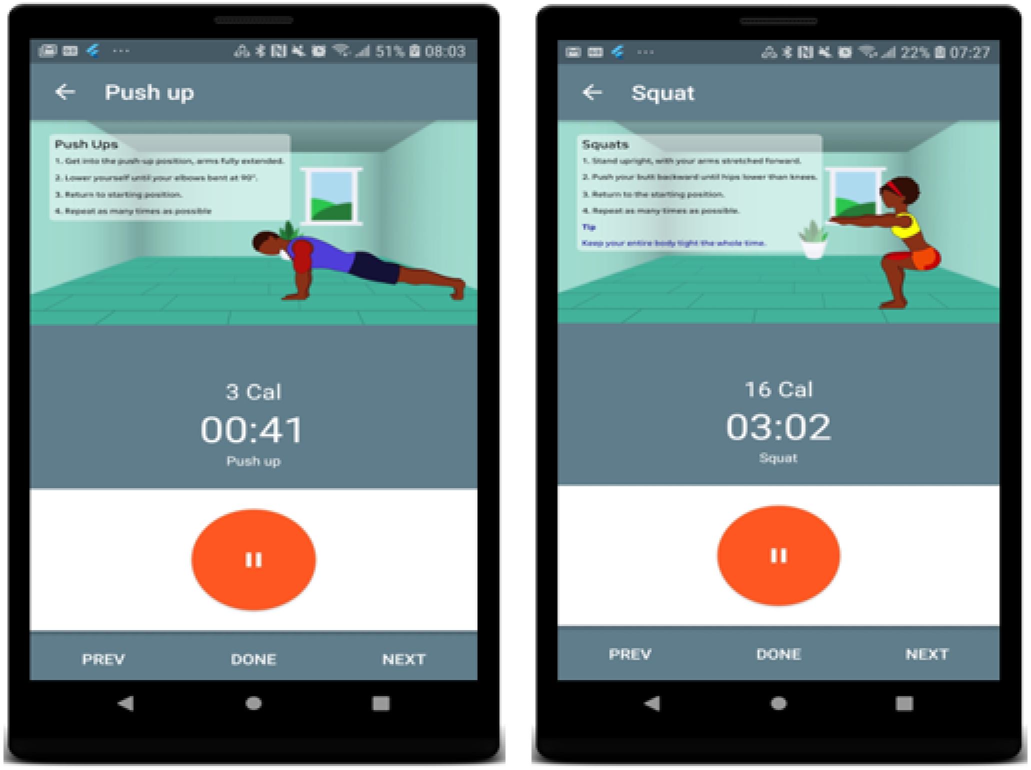

Figure 7.16: Behavior Model and Exercise Timer features

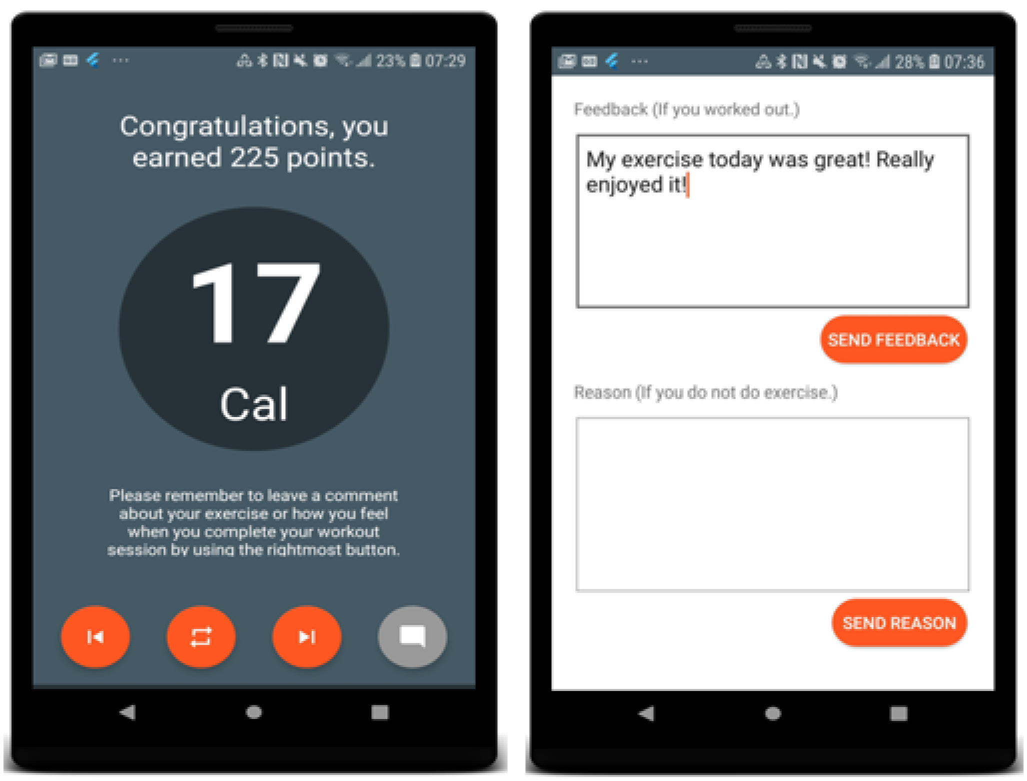

Figure 7.17: Reward feature and user's feedback interface

Reward. This is an incentive-based persuasive feature, which allows the users to earn points for the duration of time they exercised (or number of calories burned). For example, as shown in Figure 7.17, the user in question burned at least 15 calories; as such, the user earned 225 points. In addition, the Reward-feature interface allows the users to provide feedback about their exercise to the researcher as shown on the right-hand of the figure. Moreover, a weekly reward (gold/silver medal) and a monthly reward (trophy) are also offered to the users for achieving their goals for the respective periods (see Figure 7.10 and Figure 7.11).

Exercise History. This user interface allows the users to view their exercise history, including the dates the exercises were performed and the calories burned. Figure 7.18 (left-hand side) shows a snippet of a PV user's history between May 32, 20019 and August 29, 2019. On the right-hand side is a snippet of two SV users' histories, which are interleaved? The Exercise History feature is another way of implementing Self-Monitoring from a historical point of view.

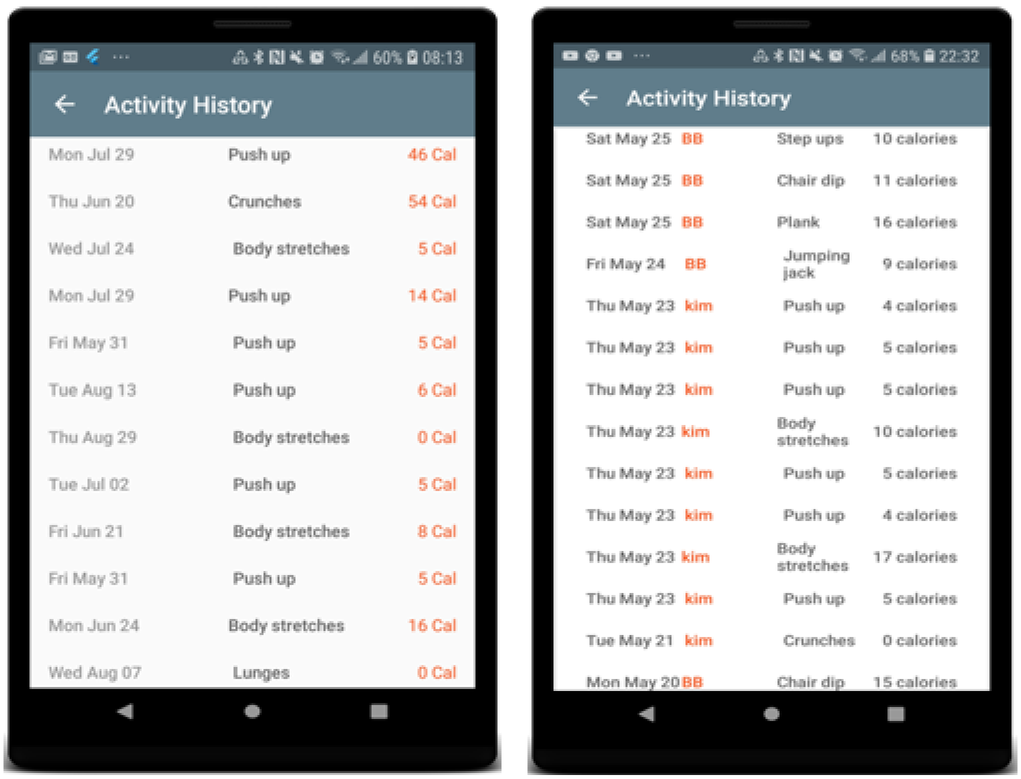

Figure 7.18: Exercise History feature: PV (left) and SV (right)

Exercise Statistics. This user interface (Figure 7.19) allows users to visualize their overall and daily physical-activity performance statistics (e.g., total/daily step count, calories burned, minutes worked out, etc.) in terms of numbers and bar charts. For example, as shown in the left user interface, in the month of July 2019, as of the 22^{nd} day, the user has taken about 360,000 steps. (Note: the statistics and figures shown in both interfaces are not real; they are simulated.)

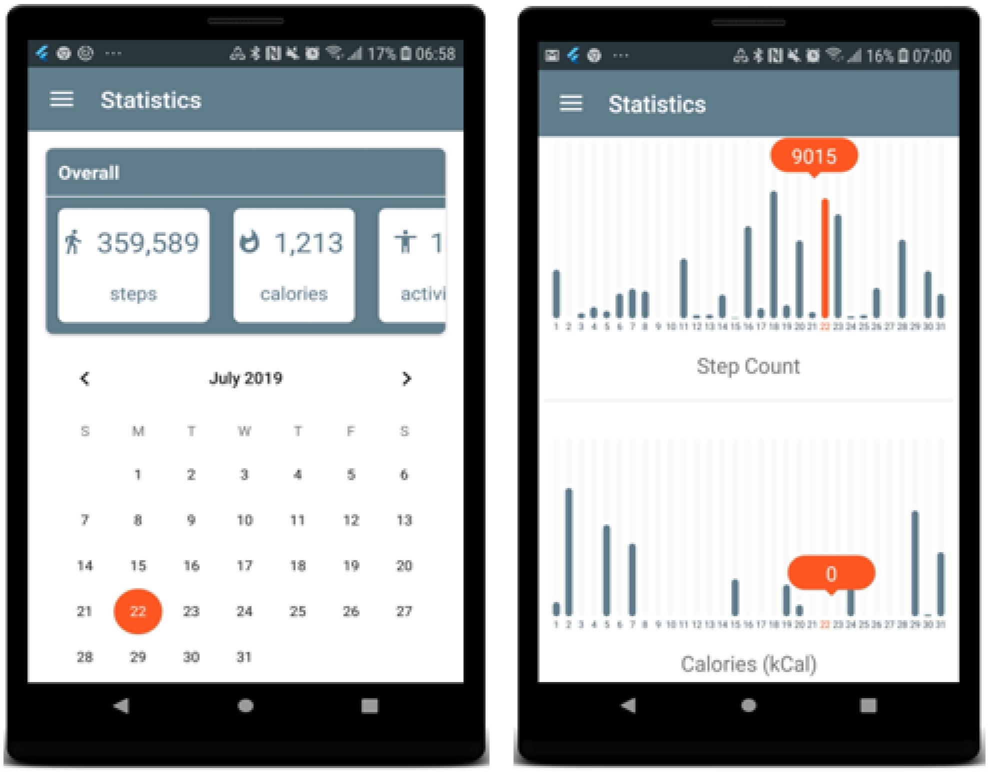

Figure 7.19: Exercise Statistics feature

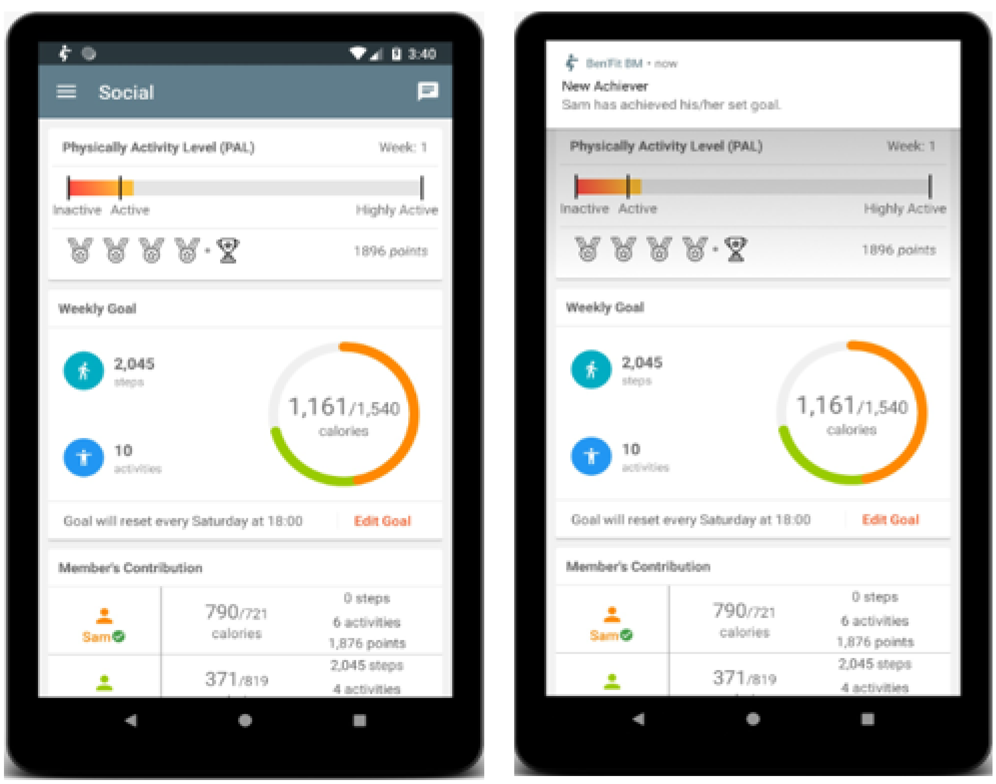

Figure 7.20: Cooperation/Social Comparison/Social Learning feature

SV Cooperation/Social Comparison/Social Learning. This is the user interface that implements the Cooperation feature. Implicitly, the Cooperation feature encapsulates the Social Comparison and Social Learning features as well. For example, in the Cooperation interface shown in Figure 7.20 (left-hand side), the two collaborative users are not only able to cooperate with each other by virtue of their goal and reward being tied together, they are able to view (learn about) and compare each other's performances. For example, User 1 (Sam) has achieved his goal (790/721 calories/week); however, User 2 has not achieved her goal (371/819). She still has about 448 calories to reach her goal of 819 calories/week. As a result, the group as a whole is yet to achieve its collective goal of 1540 calories/week, making it unable to receive its gold medal reward for the week (Week 1). Moreover, on the right-hand side of Figure 7.20 is another (explicit) implementation of Social Learning. When User 1 (Sam) completes his goal, User 2 is notified as shown by the message, "*Sam has achieved his/her goal.*"

SV Chat App. This social feature allows the users of the SV version of the BEN'FIT app to communicate with one another (or each other) about their exercise and goals. It is located on the top-right-hand corner of the homepage of the app. Figure 7.21 shows a snippet of peer-to-peer communication between two hypothetical users (Kim and BB) who are cooperating to motivate each other to exercise more.

Figure 7.21: Chat App feature

Help and Health Information. The Help and Information pages are located on top-right corner of the homepage. The Help provides the users with information on how to use the BEN'FIT app (see Figure 7.22). Basically, it describes the functionalities (menu items) and usability of the key features of the app, e.g., Goal-Setting, Settings, Reward, Chat App (in the case of the social version), etc. On the other hand, the Information page contains basic health information the users may need to know to guide their exercise. Examples of such health information include benefits of exercise, types of exercise, BMI, World Health Organization's physical activity recommendations, etc.

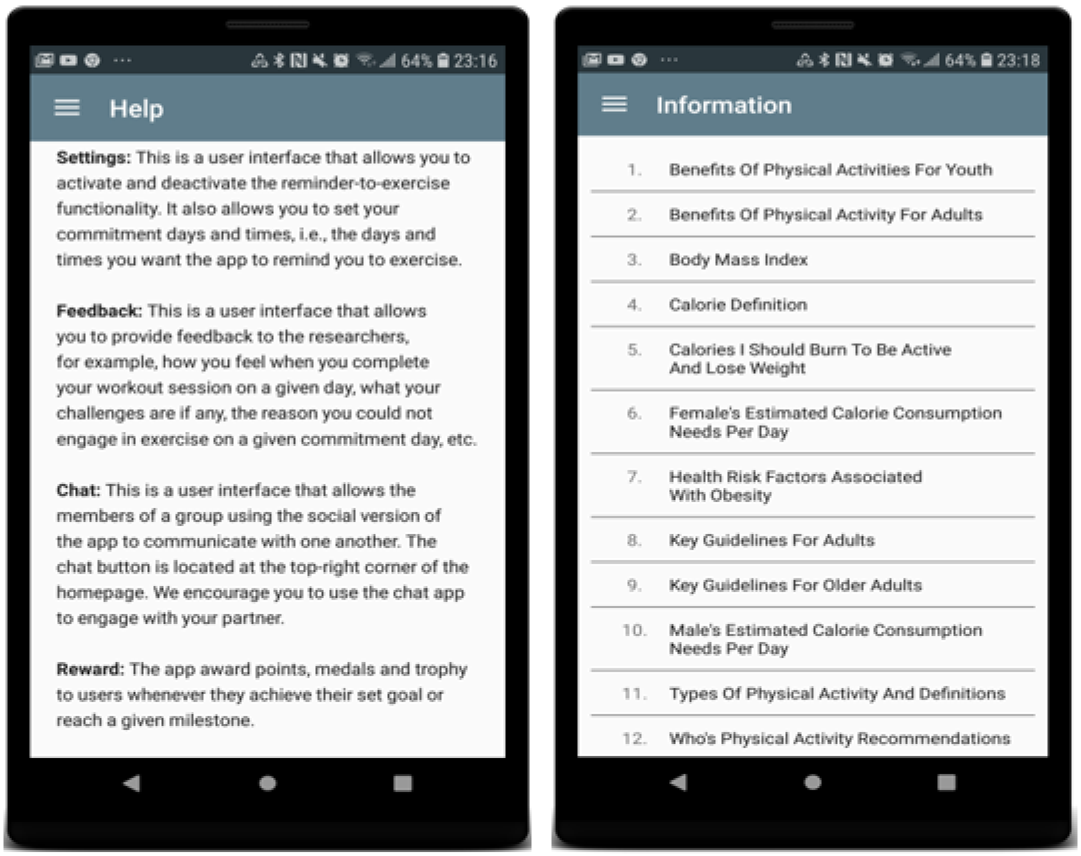

Figure 7.22: Help and Health Information pages

7.5 User Interface Design of EXLOGGER

In this section, I discuss the control version (CV), called EXLOGGER (Figure 7.23), against which the effectiveness of the intervention versions (PV and SV) will be evaluated. As the name implies, the CV version is basically a logger app, which is used to log the exercises (activities) engaged in by users over the four-week period of the field study. Overall, the CV app comprises three primary functionalities (Timer, Activities and Steps) organized in tabs and two secondary functionalities (Help and Health Information) shown at the top-right corner of the screen.

Timer. This interface helps the users to time their bodyweight exercise (e.g. push up, squat, crunch, etc.). To begin an exercise, the users click on the "Play" button. Once they are done with their exercise, they can then swipe left to the "Activities" tab to log their exercise (name and duration) and provide feedback to the researcher if they choose to.

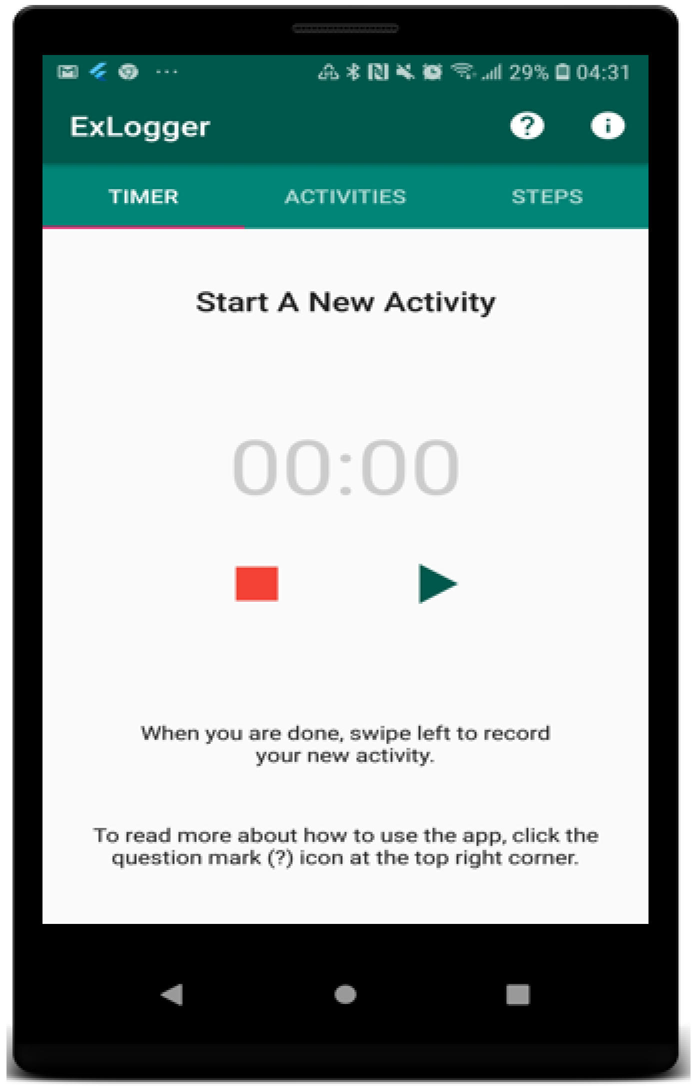

Figure 7.23: Timer interface of CV app used to time user's activities (exercises)

Activity Logger and Step Counter. The activity logger (Figure 7.24) helps users to log their exercises (names and durations). In addition, it gives the users the opportunity to provide feedback on their feeling after completing their workout. Besides, in days the users could not exercise, they are encouraged to provide feedback as well by entering "No exercise," "0 minutes," and the particular reason(s) for not exercising. Moreover, the step counter helps the users to automatically log and keep track of their daily step count over time. For example, on July 16, 2019, as shown in Figure 7.24, the user in question took 6929 steps.

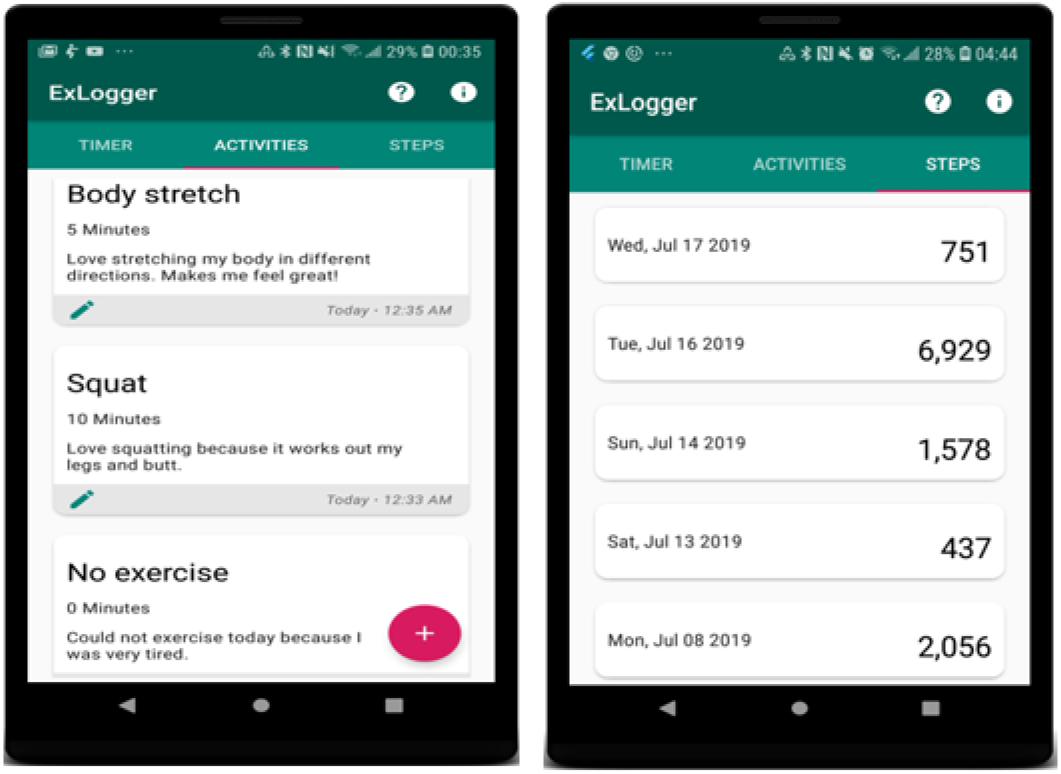

Figure 7.24: EXLOGGER Activity Logger and Step Counter

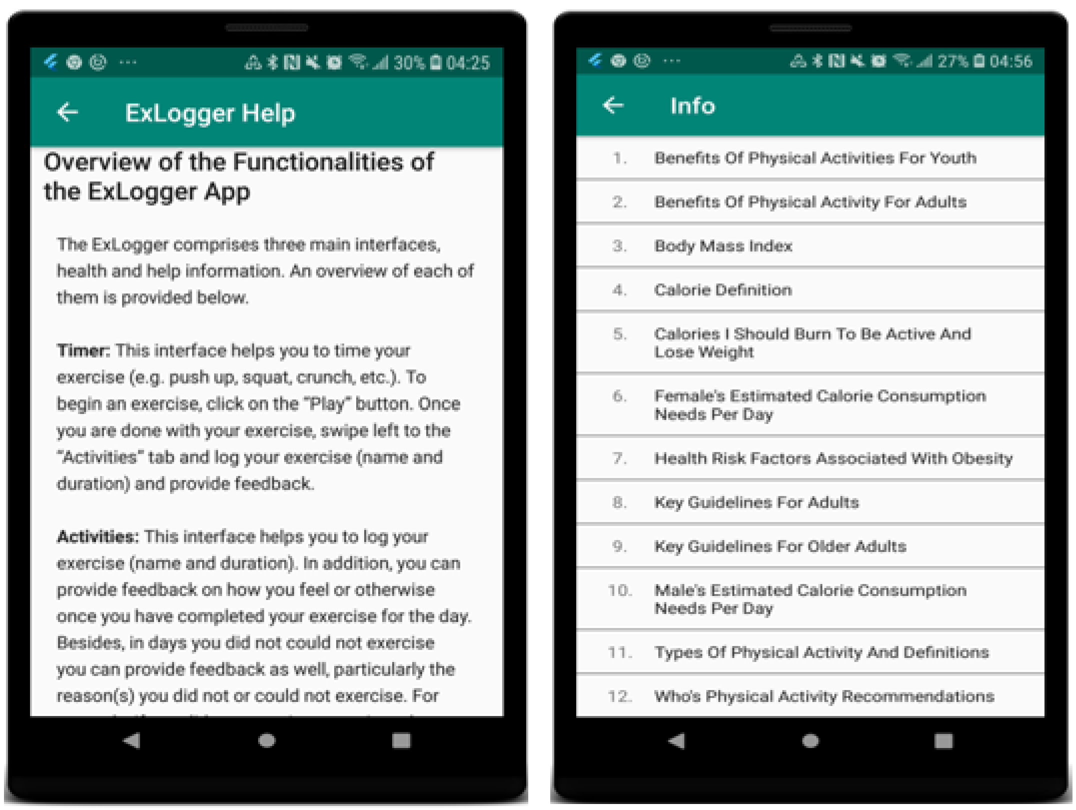

Figure 7.25: EXLOGGER Help and Health Information pages

Help and Health Information. The Help and Information pages (Figure 7.25) are located on top-right corner of the homepage. The Help provides the user with information on how to use the EXLOGGER app. The EXLOGGER Help is similar to that of BEN'FIT. Basically, it describes the functionalities and usability of the features of the app, e.g., Timer, Step Counter, Activity Logger, etc. Moreover, the Information page contains basic health information the users may need to know to support and guide their exercise. This health information page is the same as that of BEN'FIT.

7.6 Difference/Similarities between BEN'FIT and EXLOGGER

The control version (EXLOGGER) differs from the intervention versions (BEN'FIT) in that it is not equipped with persuasive features such as Goal-Setting, Self-Monitoring (based on aggregated personal informatics data over time), Reward, Behavior Model, Cooperation, Social Learning, etc. For this reason, users can only use the CV app to log and view their exercises, automatically track and view their step count, immediately or at a later date. However, the EXLOGGER app is similar to the BEN'FIT app in that both of them have a Timer, Step Counter, Activity Tracker, Help and Health Information.

7.7 User Sign Up for BEN'FIT and EXLOGGER

Prior to using the BEN'FIT and EXLOGGER apps, potential users are expected to sign up using their participation code and by providing their personal information such as age, weight, height, country and race, which is required by the app and for data analysis. Specifically, after consenting, users are required to signed up with a Gmail account, which enables the app to access Google cloud-based services (e.g., Firebase and Google Fit APIs), which it needs to function properly. In the BEN'FIT app, personal information such as weight enables the app to compute user-specific information (e.g., BMI, calories burned, etc.), which the user can access any time.

8 Pre-Evaluation of Culture-Tailored Persuasive Health Application Prior to Usage in the Field

This chapter focuses on the pre-evaluation of the actual persuasive health application (PHA) prior to its usage in the field. Figure 8.1 shows its situation in the EMVE-DeCK Framework. Prior to the evaluation of the PHA, I conducted two investigations in the pre-intervention stage. The first investigation (S4a) examines the user experience (UX) design attributes that *explain* the target audience's *intention to use* the PHA in the field. The second investigation (S4b) examines the target audience's perception profile regarding the four main UX design attributes of the PHA to determine whether they meet the target users' requirements.

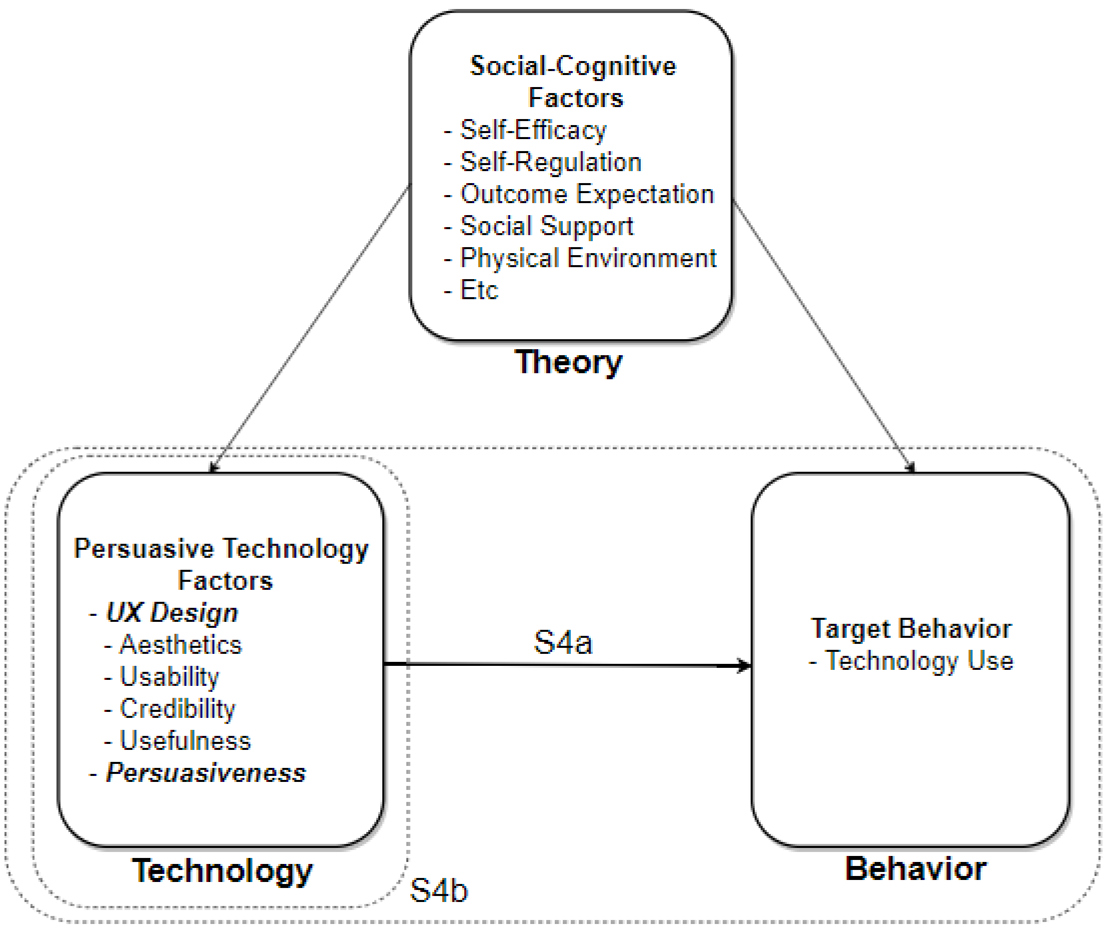

Figure 8.1: Situating the pre-evaluation of the PHA intervention in the EMVE-DeCK Framework

8.1 Motivation

Recall that, in the Persuasive Technology Acceptance Model (PTAM) for the PHA prototype in S3a (Section 6.4), the total-effect analysis results showed that *perceived aesthetics* and *perceived usefulness* are the strongest determinants of the *intention to use* a PHA. Moreover, the thematic analysis of participants' comments in S3b (Section 6.5) provided qualitative evidence for the importance of both UX design attributes in the evaluation of a PHA. As a follow-up, the results from the current investigations (S4a and S4b) will serve two purposes. First, it will help to test the generalizability of the findings that, regardless of culture, *perceived aesthetics* and *perceived usefulness* are the strongest UX design attributes that can explain users' *intention to use* a PHA. Second, it will help to uncover whether the actual PHA meets the users' UX design requirements—particularly whether the target users perceived the PHA as *visually appealing* (*perceived aesthetics*) and *functionally beneficial* (*perceived usefulness*). The perceived levels of both UX design attributes will help provide insight into the actual adoption rate among those who completed the pre-intervention study. In the light of the evaluation, adoption rate is defined as the percentage of the pre-intervention study participants who downloaded the app from Google Play Store, installed it on their mobile phone and used it to motivate their behavior change during the four-week period in which the intervention was evaluated.

8.2 Study Objective

In line with the motivation, the main objective of the current study (S4) is to answer the fifth research question of this dissertation (RQ5), "***How can we evaluate the UX design of an actual PHA prior to its usage in the field?***" This research question is broken down into the following two subquestions:

RQ5a. Does the UX design determinants of the *intention to use* a PHA (prototype) generalize to an actual application (evaluated in the field)?

RQ5b. Does the actual PHA meet the UX design requirements for its acceptance by the target audience?

8.3 Study Method

To answer the research questions, I recruited participants from the collectivist and individualist cultures to evaluate the three versions of the PHA in a pilot study in the field. The pilot study comprises a pre-intervention and an intervention stage. The pre-intervention study addresses the first two subquestions (RQ5a and RQ5b) in two investigations (S4a and S4b).

8.3.1 Study Design

The pre-intervention study employed a quantitative approach to answer the two subquestions. The study participants responded to a pre-intervention questionnaire on the UX design attributes of the PHA.

8.3.2 Data Collection

The study was submitted to the University of Saskatchewan Behavioral Research Ethics Board for review. After approval, it was posted on Amazon Mechanical Turk, Facebook and LinkedIn to recruit potential participants from Canada/United States (individualist culture) and Nigeria (collectivist culture). See Appendix D for the participants' consent forms. The aim of the recruitment was to preselect participants for the evaluation of the PHA in the field. In appreciation of their time, each participant from Canada/United States and Nigeria was compensated with US $0.50 and a N200 Nigerian phone-credit card, respectively.

Participants Preselection

A total of 202 participants expressed interest in the evaluation of the PHA: 115 were from the collectivist culture (Nigeria) and 87 were from the individualist culture (Canada/United States). In the recruitment, the participants were requested to provide information about themselves such as gender, race, country of origin, education, app version preference, gym status (currently going or not), app use status (currently using a fitness app, currently not using a fitness app or used a fitness app before), etc. Regarding app version preference, 118 chose to use it alone, i.e., the personal version (PV), while 76 chose to use it with a partner, i.e., the social version (SV). The other 8 participants chose neither (i.e., "Other"). Among the 194 participants (116 collectivists and 78 individualists) that chose to use the app alone or with a partner, there were cultural differences as shown in Figure 8.2. In the collectivist culture, 50% of the participants said they would like to use the app alone and with a partner. However, in the individualist culture, about 77% and 23% said they would like to use the app alone and with a partner, respectively. This data suggests that the PV and SV versions are more likely to be effective in the individualist and collectivist cultures, respectively.

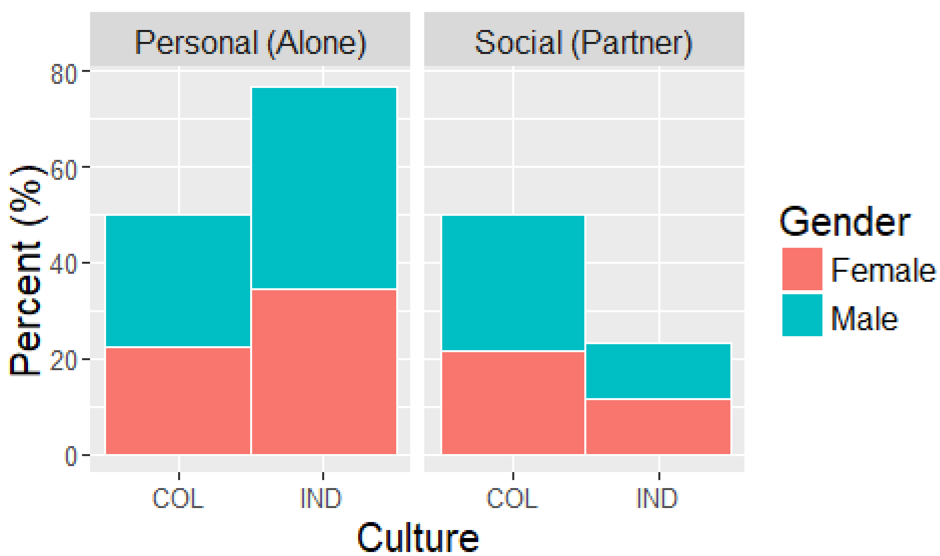

Figure 8.2: Culture-specific percentages of 194 participants (116 collectivists and 78 individualists) that preferred to use the fitness app alone and with a partner. Eight (8) participants preferred neither.

Pre-Intervention Participants

Among the 202 participants that expressed interest in participating in the evaluation of the PHA, 185 were preselected and emailed the pre-intervention questionnaire. The preselected participants were Nigerians and Canadians/Americans resident in Nigeria and Canada/United States, respectively. They reported they were not gym goers and not using a fitness app at the time of the study. See Appendix E and Appendix F for the participants' invitation and consent forms, respectively. Of the 185 participants emailed, 87 (53 collectivists and 34 individualists) completed the questionnaire prior to downloading the app from Google Play Store. Table 8.1 shows the demographics of the 87 valid participants after data cleaning. Particularly, among the 34 individualist participants, 30 were from Canada and 4 were from the United States. Moreover, of the 87 participants that took the survey, 64.4% were males and 35.6% were females. Finally, 41.4%, 49.4% and 9.2% of the participants responded to the questionnaire related to the PV, SV and CV versions of the app, respectively. In appreciation of their time, each participant from Canada/United States and Nigeria was compensated with US $1.50 and a N200 Nigerian phone-credit card, respectively.

Table 8.1: Demographics of pre-intervention participants who evaluated the perceived UX design of the actual PHA. PV = Personal Version, SV = Social Version, CV = Control Version.

		Number			**Percent**		
Criterion	**Subgroup**	**COL**	**IND**	**OVERALL**	**COL**	**IND**	**OVERALL**
Gender	Female	15	16	31	28.3	47.1	35.6
	Male	38	18	56	71.7	52.9	64.4
Age	18-24	7	5	12	13.2	14.7	13.8
	25-34	19	7	26	35.8	20.6	29.9
	35-44	3	16	19	5.7	47.1	21.8
	45-54	1	2	3	1.9	5.9	3.4
	Unspecified	23	4	27	43.4	11.8	31.0
Country of Origin	Canada	0	30	30	0.0	88.2	34.5
	United States	0	4	4	0.0	11.8	4.6
	Nigeria	53	0	53	100.0	0.0	60.9
App Version	PV	23	13	36	43.4	38.2	41.4
	SV	26	17	43	49.1	50.8	49.4
	CV	4	4	8	7.5	11.8	9.2

8.3.3 Measurement Instruments

Regarding RQ3a and RQ3b, quantitative scales were used to measure the perceived UX design attributes of the PHA and the related constructs of interest. Specifically, the TAM-related questions employed in the evaluation of the UX design of the PHA prototype in S3 (see Table 6.1) were presented to the pre-intervention study participants as well alongside a snapshot of the homepage of the actual PHA (PV or SV or CV). Prior to downloading the app from Google Play Store, the participants were requested to rate the snapshot of one of the versions of the PHA in terms of six constructs. They include *perceived aesthetics*, *perceived usability*, *perceived credibility*, *perceived usefulness*, *perceived persuasiveness* and *intention to use*. In particular, the question for *intention to use* was modified from S3's "*Assuming the app was deployed in real life, I predict that I will use it if I have the opportunity*" to simply "*I will use the app to motivate my exercise*." All of the constructs employed a 7-point Likert scale ranging from "Strongly Disagree (1)" to "Strongly Agree (7)."

8.4 S4a: Investigation of the UX Design Determinants of the Acceptance of an Actual PHA among the Target Audience and the Moderating Effect of Culture: a Quantitative Approach

This investigation (S4a) aims to uncover the most important UX design attributes that determine the acceptance of an actual PHA, the mediating effect of *perceived persuasiveness* and the moderating effect of culture. Most importantly, it aims to triangulate its findings with those based on the PHA prototype presented in Chapter 6. In this investigation, I present the research questions, study participants, research model, data analysis, results, discussion and triangulation of the findings from S3a and S4a.

8.4.1 Research Questions

S4a aims to address the research question (RQ5a), "*Does the UX design determinants of the intention to use a PHA (prototype) generalize to an actual application (evaluated in the field)?*" It is broken down as follows:

RQ5a-i. Which of the four commonly known UX design attributes is/are the strongest determinants of the *intention to use* an actual PHA?

RQ5a-ii. Does the inclusion of *perceived persuasiveness* in the PTAM improve the model?

RQ5a-iii. Is the effect of *perceived usefulness* on *intention to use* mediated by *perceived persuasiveness*?

RQ5a-iv. Are the interrelationships among the perceived UX design constructs in the PTAM moderated by culture?

Recall, in S3a, in the context of PTAM, I found that: (1) regardless of culture, *perceived usefulness* and *perceived aesthetics* are the strongest UX design determinants of the *intention to use* a PHA; (2) the direct effect of *perceived usefulness* on *intention to use* is stronger in the collectivist model than in the individualist model; and (3) *perceived persuasiveness* is more likely to mediate the effect of *perceived usefulness* on *intention to use* in the individualist model than in the collectivist model. While S3a's findings are based on a PHA prototype, S4a aims to investigate the replication of the said findings using an actual PHA.

8.4.2 Research Model and Hypotheses

To answer S4a's subquestions, I adopted the research model shown in Figure 8.3, which was initially presented in S3a. See Section 6.4.2 for the grounding of the hypothesized relationships in the literature.

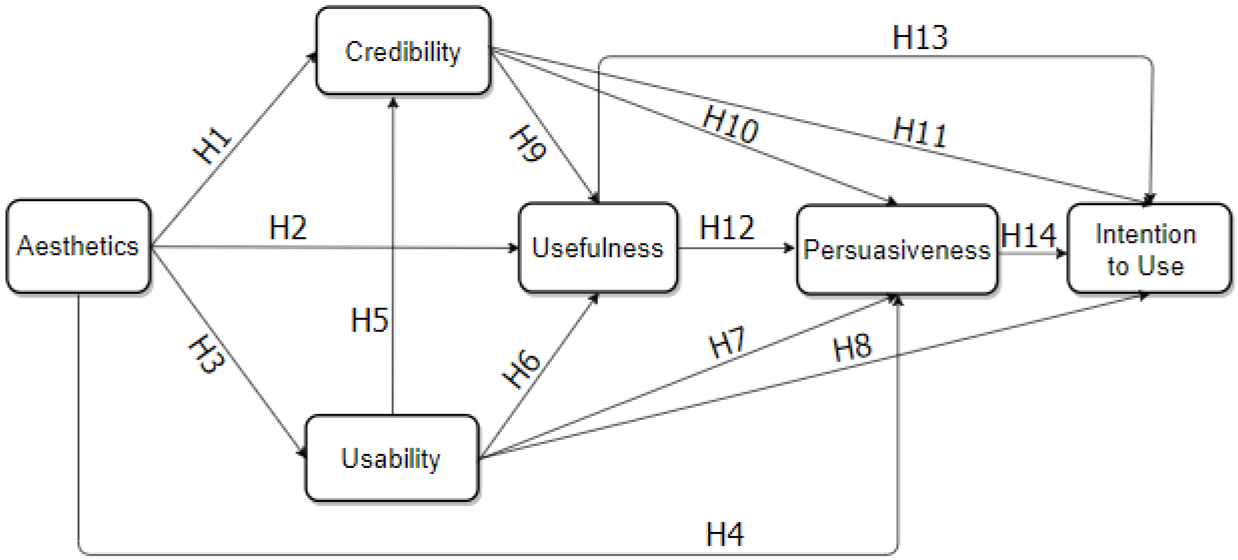

Figure 8.3: Hypothesized model of an actual persuasive technology acceptance

8.4.3 Data Analysis and Results

I employed PLSPM in addressing the subquestions. In this section, I present the results, including the evaluation of the measurement models, analysis of the structural models, adjusted R-squared, total effect, mediation and multigroup analyses.

Evaluation of the Measurement Models

Prior to analyzing the culture-specific structural models, I assessed the measurement models in order to ensure that the preconditions (the criteria to evaluate the structural models) were met [74][170]. The preconditions, their definitions and the overall results of the evaluation of the measurement models are shown in Table 6.3. They include indicator reliability, internal consistency reliability, convergent validity and discriminant validity. All of the criteria were met prior to building and analyzing the structural models.

Structural Analysis of the Collectivist Model

Figure 8.4 shows the collectivist model. The goodness of fit (GOF) for the model is 82%, which is a large value in the PLSPM community [187]. The coefficient-of-determination (R^2) values for the four endogenous constructs are above 85% (which is considered a high value [74]), with that of *perceived credibility* being the highest (98%), followed by that of *perceived usability* (91%) and *perceived persuasiveness* (90%). Overall, five of the 14 hypothesized relationships are statistically significant. Specifically, the relationships between *perceived aesthetics*, on one hand, and *perceived usability* ($\beta = 0.95$, $p < 0.001$), *perceived usefulness* ($\beta = 0.93$, $p < 0.001$) and *perceived credibility* ($\beta = 0.93$, $p < 0.001$), on the other hand, are the strongest. However, those between *perceived usefulness*, on one hand, and *perceived persuasiveness* ($\beta = 0.68$, $p < 0.001$) and *intention to use* ($\beta = 0.67$, $p < 0.001$), on the other hand, are the least strong of the significant relationships. Although the path coefficient of the relationship between *perceived persuasiveness* and *intention to use* is above 0.2 ($\beta = 0.28$, $p > 0.05$), which is considered strong numerically, it is not statistically significant.

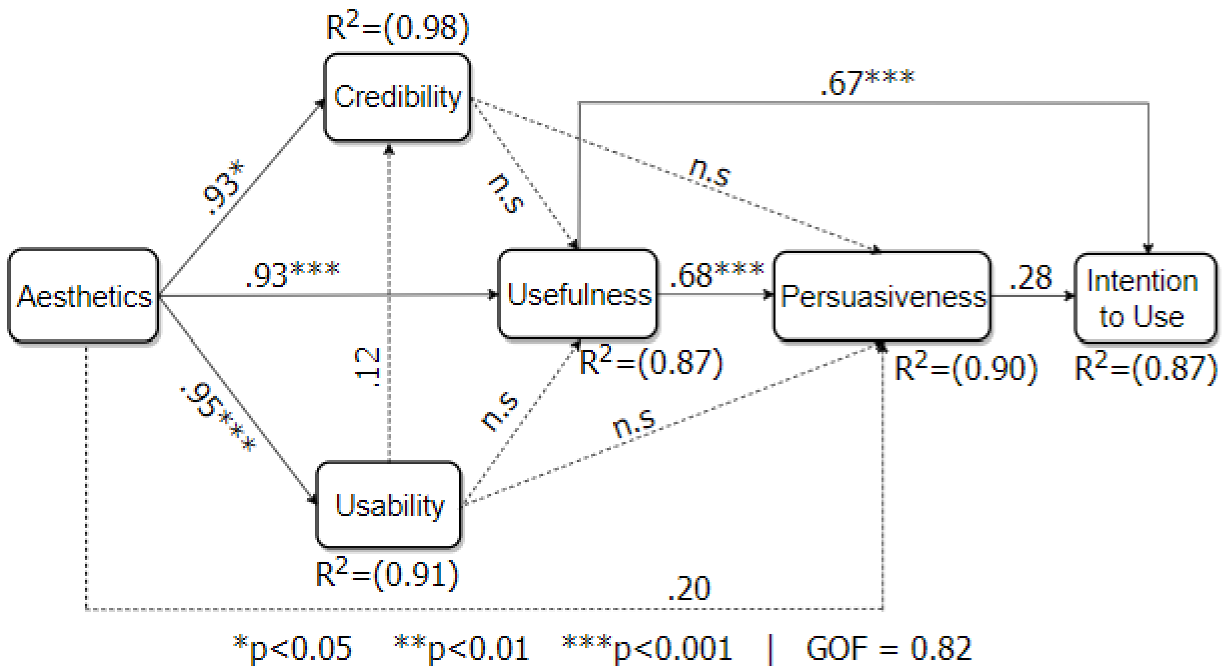

Figure 8.4: Collectivist persuasive technology acceptance model for an actual PHA (relationship unshown or labeled "n.s" is a non-significant path coefficient excluded from the model when it was built)

Structural Analysis of the Individualist Model

Figure 8.5 shows the individualist model. The GOF for the model is 78%, which is considered a high value, just as that of the collectivist model [187]. The R^2 value for *perceived persuasiveness* turns out to be the highest (93%), followed by that of *perceived usefulness* (92%) and *intention to use* (84%). All of these three R^2 values are regarded as high given that they are over 60% [74]. Overall, six of the 14 hypothesized relationships in the individualist model are significant and strong given that they are way above ($\beta = 0.20$, $p < 0.05$). Among them, the relationship between *perceived aesthetics* and *perceived usefulness* is the strongest ($\beta = 0.92$, $p < 0.001$), followed by that between *perceived aesthetics* and *perceived usability* ($\beta = 0.89$, $p < 0.001$). On the other hand, the relationship between *perceived aesthetics* and *perceived persuasiveness* ($\beta = 0.49$, $p < 0.05$) is the least of the strong.

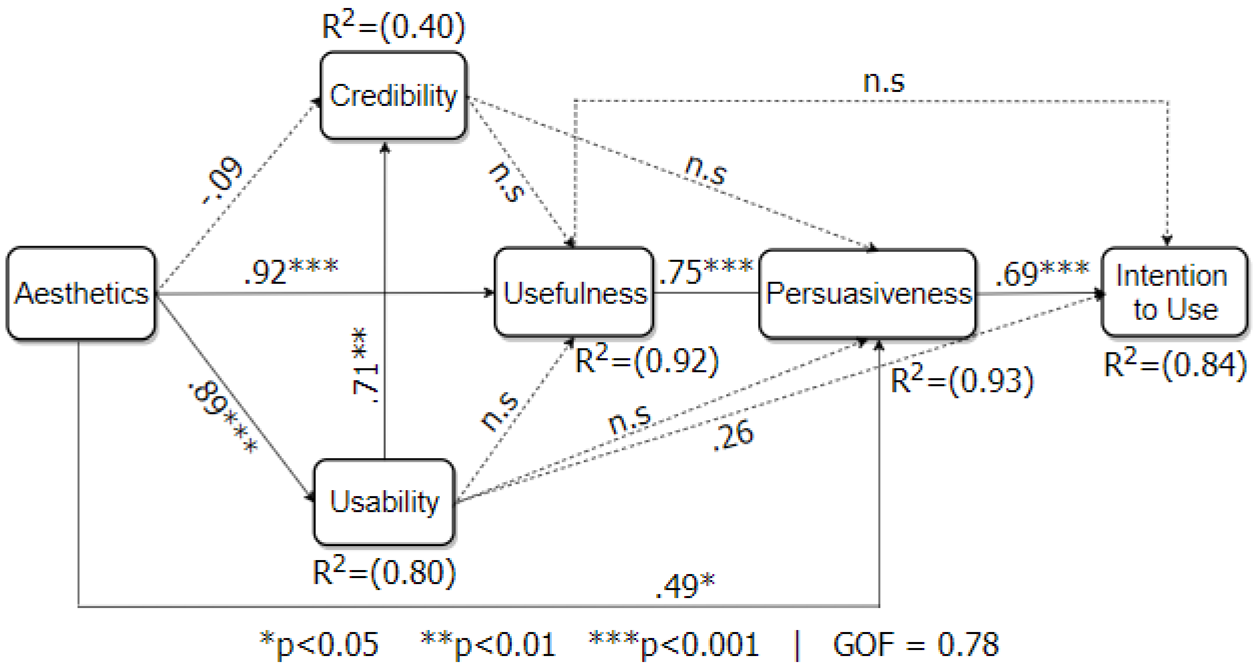

Figure 8.5: Individualist persuasive technology acceptance model for an actual PHA (relationship unshown or labeled "n.s" is a non-significant path coefficient excluded from the model when it was built)

Effect Size and Cultural Difference

To uncover the magnitude of the effect of the two proximal constructs (*perceived usefulness* and *perceived persuasiveness*) on *intention to use* and the cultural difference, I conducted an effect-size analysis [72]. See Equation 4.2 on how to calculate the effect size. The result (Table 8.2) shows that *perceived usefulness* has a large effect size on *intention to use* in the collectivist model (f^2 = 0.38), but no (negative) effect size in the individualist model (f^2 = -0.17). However, *perceived persuasiveness* has a large effect size on *intention to use* in the individualist model (f^2 = 0.44), but a negative effect size in the collectivist model (f^2 = -0.92). The negative effect size indicates the collectivist model is better off with *perceived persuasiveness* excluded. However, the large effect size of *perceived persuasiveness* on *intention to use* in the individualist model indicates that *perceived persuasiveness* is important and thus should be kept in the model.

Table 8.2: Effect size of proximal constructs on intention to use for an actual PHA. $f^2 = 0.02$: small, $f^2 = 0.15$: medium, $f^2 = 0.35$: large [72]. R^2_{inc} and R^2_{exc} are the coefficients of determination when the proximal construct is included and excluded from the model, respectively. Bold effect size is large.

	COL			**IND**		
Proximal Construct	R^2_{inc}	R^2_{exc}	f^2	R^2_{inc}	R^2_{exc}	f^2
Perceived Usefulness	0.87	0.82	**0.38**	0.84	0.87	-0.17
Perceived Persuasiveness	0.87	0.99	-0.92	0.84	0.77	**0.44**

Total Effect Analysis

To answer the first subquestion (RQ5a-i), "*Which of the four commonly known UX design attributes is/are the strongest determinants of the intention to use an actual PHA?*," I conducted a total-effect analysis. Figure 8.6 shows the total effect of the perceived UX design constructs on *intention to use* for the two cultural groups. The results show that the strongest of the total effects are those of *perceived aesthetics* and *perceived usefulness* on *intention to use*, which are above (β_T = 0.80, $p < 0.001$) in both culture-specific models, except that of *perceived usefulness* in the individualist model, which is less than half ($\beta_T < 0.40$, $p < 0.001$). Moreover, the proximal construct, *perceived persuasiveness*, only has a significant total effect on *intention to use* in the individualist model ($\beta_T = 0.69$, $p < 0.001$). Although the total effect of *perceived persuasiveness* on *intention to use* in the collectivist model ($\beta_T = 0.28$, $p > 0.05$) is above 0.20, it is not significant at $p <$ 0.05. Finally, regardless of culture, *perceived usability* and *perceived credibility* do not have a significant total effect on *intention to use*, although, in the individualist model, the path coefficient for *perceived usability* (β_T = 0.27, $p > 0.05$) is greater than 0.20.

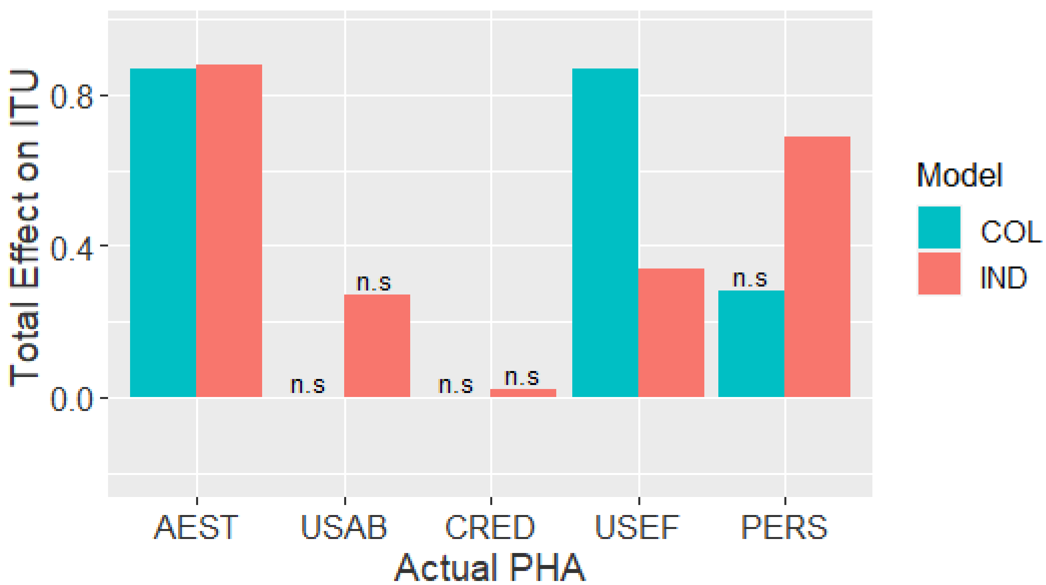

Figure 8.6: Total Effect of perceived UX design constructs on intention to use based on an actual PHA. Each construct without a label is significant at $p < 0.001$.

Adjusted R-Squared Analysis

To answer the second subquestion (RQ5a-ii), "*Does the inclusion of perceived persuasiveness in the PTAM improve the model?*," I built the culture-specific models with *perceived persuasiveness* excluded from the model. Table 8.3 shows the R^2 and R^2_{Adj} values for both versions of models. The first version is based on the exclusion of *perceived persuasiveness* in the model and the second version on its inclusion from the model. It is evident that, for the individualist model, the R^2_{Adj} value increases from 74% to 81% (difference – 7%). However, for the collectivist model, the R^2_{Adj} value of *intention to use* decreases from 99% to 86% (difference – 13%). These results are an indication that, for the individualist model, the inclusion of *perceived persuasiveness* in the PTAM improves the model, but the reverse is the case for the collectivist model.

Table 8.3: R-squared adjust value for intention to use when perceived persuasiveness is included and excluded from the PTAM for an actual PHA. Bold value is greater than its counterpart.

	R^2		R^2_{Adj}	
Perceived Persuasiveness	**COL**	**IND**	**COL**	**IND**
Excluded from model	**0.99**	0.77	**0.99**	0.74
Included in model	0.87	**0.84**	0.86	**0.81**

Mediation Analysis

To answer the third subquestion (RQ5a-iii), "*Is the effect of perceived usefulness on intention to use mediated by perceived persuasiveness?*," I conducted a mediation analysis with regard to *perceived usefulness*, *perceived persuasiveness* and *intention to use*. The results (Table 8.4) show that when *perceived persuasiveness* is excluded from the individualist model, the direct effect of *perceived usefulness* on *intention to use* is (β = 0.87, $p < 0.001$). However, this path coefficient decreases to (β = -0.45, $p = n.s$) in the individualist model when *perceived persuasiveness* is included.

Table 8.4: Variance accounted for by indirect path in the PTAM for an actual PHA. β_{dir} = direct path coefficient for USEF $\rightarrow$ ITU when PERS is excluded from the model. β_{indir} = indirect path coefficient for USEF $\rightarrow$ PERS $\rightarrow$ ITU. VAF = Variance Accounted For by indirect path. $VAF = 0.2$: partial mediation, $VAF = 0.8$: full mediation [72]. The bold value is greater than its counterpart.

	β_{indir}	β_{dir}	VAF
COL	0.19	0.91	0.17
IND	0.52	0.87	**0.37**

The Variance Accounted For (VAF) by the mediation (indirect) path is 0.37. These results indicate that *perceived persuasiveness* partially mediates the direct effect of *perceived usefulness* on *intention to use* in the individualist model. Moreover, in the collectivist model, when *perceived persuasiveness* is excluded from the model, the direct effect of *perceived usefulness* on *intention to use* is (β = 0.91, $p < 0.001$). On inclusion of *perceived persuasiveness* in the model, the direct effect of *perceived usefulness* on *intention to use* decreases to (β = 0.67, $p < 0.001$). Although, there is a decrease in the said effect, the computed VAF (0.17), which is less than 0.20, indicates there is no mediation of the said relationship by *perceived persuasiveness*. The fact that the relationship between *perceived persuasiveness* and *intention to use* (β = 0.28, $p = n.s$) is not significant in the collectivist model (a condition for carrying out a mediation analysis) also confirms the lack of mediation of the relationship between *perceived usefulness* and *intention to use* by *perceived persuasiveness.*

Multigroup Analysis

To answer the fourth subquestion (RQ5a-iv), "*Are the interrelationships among the perceived UX design constructs in the PTAM moderated by culture?*," I conducted a multigroup analysis. The results (Table 8.5) show that both cultures significantly differ in four relationships. The first two concern *perceived credibility* and the other two concern *intention to use*. *Perceived aesthetics* has a significant effect on *perceived credibility* in the collectivist model (β = 0.93, $p < 0.001$), but a non-significant effect in the individualist model. In contrast, *perceived usability* has a significant effect effect on *perceived credibility* in the individualist model (β = 0.71, $p < 0.001$), but a non-significant effect in the collectivist model. Moreover, *perceived usefulness* has a significant effect on *intention to use* in the collectivist model (β = 0.67, $p < 0.001$), but a non-significant effect in the individualist model. In contrast, *perceived persuasiveness* has a significant effect on *intention to use* in the individualist model (β = 0.69, $p < 0.001$), but a non-significant effect in the collectivist model.

Table 8.5: Multigroup analysis showing where the collectivist and individualist cultures significantly differ (bold rows) in the PTAM relationships for an actual PHA. "-" means the path coefficient is less than 0.02 and/or not significant. "*" : $p < 0.05$, "**" : $p < 0.01$, "***" : $p < 0.001$.

Relationship	COL	IND	*p*-Value	Sig.
AEST → USAB	0.95***	0.89***	0.2307	No
AEST → CRED	**0.93*** **	**-**	**0.0480**	**Yes**
AEST → USEF	0.93***	0.92***	0.1034	No
AEST → PERS	0.20	0.49*	0.0513	No
USAB → CRED	**-**	**0.71*** **	**0.0420**	**Yes**
USAB → USEF	-	-	0.2982	No
USAB → ITU	-	0.26	0.2491	No
CRED → USEF	-	-	0.1819	No
CRED → PERS	-	-	0.3101	No
CRED → ITU	-	-	0.3821	No
USEF → PERS	0.68***	0.75***	0.0601	No
USEF → ITU	**0.67*** **	**-**	**0.0408**	**Yes**
PERS → ITU	**0.28**	**0.69*** **	**0.008**	**Yes**

8.4.4 Discussion

I have presented a PTAM on the perceived UX design attributes that explain the acceptance of an actual PHA, the mediating effect of the relationship between *perceived usefulness* and *intention to use* by *perceived persuasiveness*, and the moderating effect of culture. Overall, the GOF values for the culture-specific models are large (over 70%), indicating that the respective models fit their empirical data well. Similarly, the

R^2 values are high (over 70%), indicating that, regardless of culture, *perceived usefulness* and/or *perceived persuasiveness* account for a large portion of the variance of *intention to use*. Table 8.6 provides a summary of the validated hypotheses. In the collectivist and individualist models, 5 and 6 of the 14 hypotheses, respectively, are validated. Specifically, as shown in Table 8.2, *perceived usefulness* has a large effect size on *intention to use* in the collectivist model, but no effect size in the individualist model. On the other hand, *perceived persuasiveness* has a large effect size on *intention to use* in the individualist model, but no effect size in the collectivist model.

Table 8.6: Summary of the validated PTAM relationships for an actual PHA. "✓" indicates that the hypothesis is supported, with the bolded one indicating that the relationship in question is greater than ($\beta = 0.20$, $p < 0.05$); "×" indicates the hypothesis is not supported; "-" indicates that the hypothesis is not supported and a negative relationship.

No.	Hypothesis	Relationship	COL	IND
H1	The perceived aesthetics of a persuasive health application will positively influence its perceived credibility.	AEST → CRED	**✓**	×
H2	The perceived aesthetics of a persuasive health application will positively influence its perceived usefulness.	AEST → USEF	**✓**	**✓**
H3	The perceived aesthetics of the persuasive health application will positively influence its perceived usability.	AEST → USAB	**✓**	**✓**
H4	The perceived aesthetics of the persuasive health application will positively influence its perceived persuasiveness.	AEST → PERS	×	**✓**
H5	The perceived usability of the persuasive health application will positively influence its perceived credibility.	USAB → CRED	×	**✓**
H6	The perceived usability of a persuasive health application will positively influence its perceived usefulness.	USAB → USEF	×	×
H7	The perceived usability of the persuasive health application will positively influence its perceived persuasiveness.	USAB → PERS	×	×
H8	The perceived usability of a persuasive health application will positively influence users' intention to use it.	USAB → ITU	×	×
H9	The perceived credibility of a persuasive health application will positively influence its perceived usefulness.	CRED → USEF	×	×
H10	The perceived credibility of a persuasive health application will positively influence its perceived persuasiveness.	CRED → PERS	×	×
H11	The perceived credibility of a persuasive health application will positively influence users' intention to use it.	CRED → ITU	×	×
H12	The perceived usefulness of a persuasive health application will positively influence its perceived persuasiveness.	USEF → PERS	**✓**	**✓**
H13	The perceived usefulness of a persuasive health application will positively influence users' intention to use it.	USEF → ITU	**✓**	×
H14	The perceived persuasiveness of a persuasive health application will positively influence users' intention to use it.	PERS → ITU	×	**✓**

The hallmark of the validated hypotheses is that they relate to *perceived aesthetics*, *perceived usefulness* and *perceived persuasiveness*, with each construct being an antecedent. This is an indication of the importance of these three UX design constructs in the PTAM for PHAs. For example, the influence of *perceived aesthetics* on *perceived usability* and *perceived persuasiveness* cut across both culture-specific models. The same goes for the influence of *perceived usefulness* on *perceived persuasiveness* and *intention to use* only that, in the individualist model, the influence is not significant due to the mediating effect of *perceived persuasiveness*. Finally, the influence of *perceived persuasiveness* on *intention to use* is above 0.2 in both models, except that, in the collectivist model, it is not significant ($\beta = 0.28$, $p > 0.05$).

Most Important UX Design Constructs in the PTAM

In the light of the first subquestion, (RQ5a-i), "*Which of the four commonly known UX design attributes is/are the strongest determinants of the intention to use an actual PHA?*," I summarized the results in Table 8.7. Without considering *perceived persuasiveness*, which is the most proximal construct in the model and situated in the user domain, perceived usefulness and *perceived aesthetics* are the strongest UX design determinants of the *intention to use* an actual PHA. Specifically, the two attributes are equally strong in the collectivist model. However, *perceived aesthetics* is the stronger than *perceived usefulness* in the individualist model. Moreover, *perceived usability* seems to be a more important determinant of *intention to use* in the individualist model than in the collectivist model, only that it is not significant ($\beta_T = 0.27$, $p = n.s$).

Table 8.7: Culture-specific profile based on the perceived UX design determinants of the intention to use an actual PHA. The underlined construct indicates a significant total effect , with solid and dashed lines representing strong ($\beta \geq 0.2$, $p < 0.05$) and weak effects, respectively. The brackets indicate the numerical difference between each pair of bracketed constructs is less than 0.05. The superscripted construct[1] indicates its total effect is greater than 0.2 but not significant at $p < 0.05$.

Model	**Order of Strength of Determinants of Intention to Use**
Collectivist	[<u>Usefulness</u>, <u>Aesthetics</u>], Persuasiveness[1], [Credibility, Usability]
Individualist	<u>Aesthetics</u>, <u>Persuasiveness</u>, <u>Usefulness</u>, Usability[1], Credibility

Importance of Perceived Persuasiveness in the PTAM

With regard to the second subquestion, (RQ5a-ii), "*Does the inclusion of perceived persuasiveness in the PTAM improve the model?*," the answer is model- or culture-dependent as shown in Table 8.3. In the individualist model, the R^2_{Adj} analysis shows that R^2_{Adj} value increases from 74% to 81% once *perceived persuasiveness* is included in the model. This suggests that the inclusion of *perceived persuasiveness* in the PTAM improves the model for the individualist culture. However, for the collectivist model, the R^2_{Adj} value of *intention to use* decreases from 99% to 86% once *perceived persuasiveness* is included in the model. In contrast, this suggests that the inclusion of *perceived persuasiveness* in the PTAM does not improve the model for the collectivist culture.

Mediating Effect of Perceived Persuasiveness in the PTAM

With regard to the third subquestion, (RQ5a-iii), "*Is the effect of perceived usefulness on intention to use mediated by perceived persuasiveness?*," again, the answer is model- or culture-dependent as I showed in the mediation analysis. The VAF value (i.e., the variance accounted for by the indirect path compared with the direct path) is 0.37 for the individualist model and 0.17 for the collectivist model. This shows that, in the PTAM for the individualist culture, *perceived persuasiveness* mediates the effect of *perceived usefulness* on intention to use. However, this is not the case for the collectivist culture.

Cultural Differences in the PTAM Relationships between Constructs

With regard to the fourth subquestion, (RQ5a-iv), "*Are the interrelationships among the UX design constructs in the PTAM moderated by culture?*," the answer is yes as shown in Table 8.5. Specifically, the relationship between *perceived aesthetics* and*perceived credibility* and that between *perceived usefulness* and *intention to use* are stronger for the collectivist culture than for the individualist culture. The first result suggests that *perceived aesthetics* is a stronger antecedent of *perceived credibility* for the collectivist culture than for the individualist culture. Moreover, the relationship between *perceived usefulness* and *intention to use* is stronger and has a larger effect size in the collectivist culture than in the individualist culture because, in the collectivist model, *perceived persuasiveness* does not mediate the relationship between both constructs as it does in the individualist model. On the other hand, the relationship between *perceived usability* and *perceived credibility* and that between *perceived persuasiveness* and *intention to use* are stronger for the individualist culture than for the collectivist culture. The first result suggests that that *perceived usability* is a stronger antecedent of *perceived credibility* for the individualist culture than for the collectivist culture. Moreover, the second result is an indication that *perceived persuasiveness* is an important construct in the PTAM for the individualist culture: it acts as a partial mediator of the effect of *perceived usefulness* on *intention to use*.

8.4.5 Triangulating the PTAM Findings based on an Actual PHA (S4a) with those based on a PHA Prototype (S3a)

Recall that the goal of S4a is to address the research question (RQ5a), "*Does the UX design determinants of the intention to use a PHA (prototype) generalize to an actual application (evaluated in the field)?*" Hence, in this section, I triangulate the findings relating to each subquestion of S4a with those from S3a.

Generalization of the Most Important UX Design Constructs in the PTAM

The first triangulation is aimed to answer the question, "*Do the strongest UX design determinants of the intention to use an PHA generalize across different application designs?*" To answer this question, I re-present the total effect analysis results from S3a and S4a side by side as shown in Figure 8.7. As evident in the plot, the answer to the posed question is yes. In a nutshell, regardless of the application design (prototype or actual) and culture, *perceived aesthetics* and *perceived usefulness* are the strongest UX design determinants of the *intention to use* a PHA. Specifically, the total effect of both constructs is greater than ($\beta_T = 0.5$, $p < 0.01$). On the other hand, the total effect of *perceived usability* and *perceived credibility* on *intention to use* is either non-significant or less than ($\beta_T = 0.25$, $p < 0.05$), except for *perceived credibility* in the collectivist model based on the PHA prototype ($\beta_T = 0.33$, $p < 0.05$). All of these findings attest to the generalizability of the finding that, "*in the context of UX design, regardless of culture, perceived aesthetics and perceived usefulness are the strongest determinants of the users' intention to use an actual PHA deployed in the field.*"

Figure 8.7: Triangulation of the total effects of UX design constructs on intention to use for an actual PHA (S4a) with those for a PHA prototype (S3a). AEST = Perceived Aesthetics, USAB = Perceived Usability, CRED = Perceived Credibility, USEF = Perceived Usefulness, PERS = Perceived Persuasiveness, ITU = Intention to Use. Each construct without a label is significant at $p < 0.001$.

Generalization of the Importance of Perceived Persuasiveness in the PTAM

The second triangulation is aimed to answer the question,"*Does the outcome of the inclusion of perceived persuasiveness in the PTAM generalize across different application designs?*" To answer this question, I re-present the R^2 and R^2_{Adj} analysis results from S3a and S4a side by side in Table 8.8. As shown, these two metrics are higher in the individualist model regardless of the application design. For example, regarding the R^2_{Adj} metric, there is an increase from 46% to 60% (PHA prototype) and from 74% to 81% (actual PHA) once *perceived persuasiveness* is included in the model. This is hardly the case in the collectivist model, which had only 2% increase in the PHA prototype (from 72% to 74%) and a decrease of 13% (from 99% to 86%) in the actual PHA once *perceived persuasiveness* is included in the model. These culture-specific results suggest that while *perceived persuasiveness* may be important in the PTAM for the Canadian/American individualist culture, it is not for the Nigerian collectivist culture.

Table 8.8: Triangualting R-squared adjust value for intention to use for an actual PHA with that for a PHAprototype when perceived persuasiveness is included and excluded from the PTAM

	PHA Prototype				**Actual PHA**			
	R^2		R^2_{Adj}		R^2		R^2_{Adj}	
	COL	**IND**	**COL**	**IND**	**COL**	**IND**	**COL**	**IND**
PERS EXC	0.74	0.47	0.72	0.46	**0.99**	0.77	**0.99**	0.74
PERS INC	0.76	**0.61**	0.74	**0.60**	0.87	**0.84**	0.86	**0.81**

Generalization of the Mediating Effect of Perceived Persuasiveness in the PTAM

The third triangulation is aimed to answer the question, "*Does the mediation or non-mediation of the effect of perceived usefulness on intention to use by perceived persuasiveness generalize across different application designs?*" To answer this question, I re-present the mediation analysis results from S3a and S4a side by side as shown in Table 8.9. As shown, the VAF values for the mediation path (*perceived usefulness* $\rightarrow$ *perceived persuasiveness* $\rightarrow$ *intention to use*) are greater than 0.2 (the condition for mediation) for the individualist model but less than 0.2 for the collectivist model. This is an indication that, "*the mediating and non-mediating effects of perceived usefulness on intention to use by perceived persuasiveness generalize across application design for the Canadian/American individualist and Nigerian collectivist cultures, respectively.*"

Table 8.9: Triangulating PTAM's perceived persuasiveness mediation results based on an actual PHA with those based on a PHA prototype. The mediation is of the relationship between perceived usefulness and intention to use. Variance Accounted For (VAF) by indirect path shown in the table. $VAF < 0.2:$ no mediation; $0.2 \leq VAF \leq 0.8:$ partial mediation; $VAF > 0.8:$ full mediation. [72].

PHA	**COL**	**IND**
Prototype	0.13	0.43
Actual	0.17	0.37

Generalization of Cultural Differences in the PTAM Relationships between Constructs

The fourth triangulation is aimed to answer the question, "*Do the interrelationships among the UX design constructs in the PTAM and the cultural differences generalize across different application designs?*" To answer this question, I re-present the validated and non-validated PTAM relationships from S3a and S4a side by side as shown in Table 8.10. As shown, the results indicate that the relationships in which *perceived aesthetics* and *perceived usefulness* are antecedents tend to cut across culture and application design. Altogether, six of such relationships are replicated across at least three of the four PTAM models. The first set of relationships includes those between *perceived aesthetics*, on one hand, and *perceived usability*, perceived credibility, *perceived usefulness* and *perceived persuasiveness*, on the other hand. Moreover, the second set of relationships include those between *perceived usefulness*, on one hand, and *perceived persuasiveness* and *intention to use*, on the other hand. Particularly, all of the six replicated relationships indicate the importance of *perceived aesthetics*, *perceived usefulness* and *perceived persuasiveness* in the PTAM, regardless of culture.

Table 8.10: Triangualting of the PTAM relationships for a PHA prototype with those for an actual PHA. "**✓**" indicates that the hypothesis is supported, with the bolded one indicating that the relationship in question is greater than ($\beta = 0.20$, $p < 0.05$); "×" indicates the hypothesis is not supported; "-" indicates that the hypothesis is not supported and a negative relationship.

		COL		IND	
No.	**Relationship**	**Prototype**	**Actual**	**Prototype**	**Actual**
H1	AEST → CRED	**✓**	**✓**	**✓**	×
H2	AEST → USEF	**✓**	**✓**	**✓**	**✓**
H3	AEST → USAB	**✓**	**✓**	**✓**	**✓**
H4	AEST → PERS	**✓**	×	✓	**✓**
H5	USAB → CRED	×	×	**✓**	**✓**
H6	USAB → USEF	**✓**	×	**✓**	×
H7	USAB → PERS	×	×	×	×
H8	USAB → ITU	-	×	×	×
H9	CRED → USEF	**✓**	×	✓	×
H10	CRED → PERS	×	×	×	×
H11	CRED → ITU	×	×	×	×
H12	USEF → PERS	**✓**	**✓**	**✓**	**✓**
H13	USEF → ITU	**✓**	**✓**	✓	×
H14	PERS → ITU	×	×	**✓**	**✓**

Finally, regarding cultural differences that cut across application design, Table 8.11 shows the multigroup analysis results from S3a and S4a. In particular, the cultural difference ($p < 0.05$) regarding the effect of *perceived usefulness* on *intention to use* (stronger in the collectivist model) cuts across application design. This confirms the finding that the said relationship is stronger in the collectivist culture than in the individualist culture. Although the effect of *perceived persuasiveness* on *intention to use* is higher for the individualist culture than for the collectivist culture in both application designs, only the cultural difference regarding the actual PHA is significant ($p < 0.01$). The non-replication of the said relationship warrants further studies.

Table 8.11: Triangulating key PTAM multigroup analysis results based on an actual PHA with those based on a PHA prototype

	PHA Prototype				Actual PHA			
Relationship	**COL**	**IND**	***p*-Value**	**Sig.**	**COL**	**IND**	***p*-Value**	**Sig.**
USEF → ITU	0.90***	0.14*	0.0013	Yes	0.67***	-	0.0394	Yes
PERS → ITU	0.42	0.66***	0.1533	No	0.28	0.69***	0.0050	Yes

8.4.6 Summary of Main Findings

The summary of the results of S4a is based on the total effect of the significant perceived UX design attributes on the *intention to use* a PHA. Overall, *perceived aesthetics* and *perceived usefulness* are the strongest UX design determinants of the *intention to use* a PHA. These findings cut across culture and application design (prototype and actual PHAs). On one hand, *perceived aesthetics* is characterized as a hedonic/affective attribute, which appeals to human emotions and fosters pleasure. On the other hand, *perceived usefulness* is characterized as a pragmatic/utilitarian attribute, which entails the benefit users derive from the usage of a persuasive system. The current investigation, coupled with the triangulation of its findings with those of S3a, shows, consistently, that both dimensions of UX design attributes are important when potential users evaluate/decide to adopt a PHA. As such, I recommend that in the design of a PHA, such as a fitness app, designers should ensure their user interface reflects both UX design attributes and strike a balance in their realization. A reasonable balance between both hedonic (*perceived aesthetics*) and utilitarian (*perceived usefulness*) UX design attributes has the potential of increasing the adoption rate of a PHA.

8.5 S4b: Investigation of the Perception Profile of the Target Audience Regarding the Perceived UX Design Attributes of an Actual PHA and the Moderating Effect of Culture: a Quantitative Approach

In this investigation (S4b), I examine the target audience's perception profile regarding the perceived UX design attributes of the BEN'FIT (PV and SV) and EXLOGGER (CV) health applications and the moderating effect of culture and app version. In addition, I examine the perception profile regarding the *perceived persuasiveness* of both applications and users' *intention to use* them. The objective of the investigation is to determine whether potential users perceive the intervention application as *visually appealing* and *functionally beneficial*, both of which are pre-requisites for the acceptance of a PHA, as I demonstrated in the PTAM in S3a and S4a. I hypothesize that, if users, at least, perceive the BEN'FIT app (PV and SV) as both aesthetic and useful, this is an indication that they desire it and thus will be willing to adopt it to motivate their behavior change [236]. In this investigation, their desire and adoption of the app are operationalized as *perceived persuasiveness* and *intention to use*, respectively.

8.5.1 Research Questions

Research has shown that PHAs are more likely to be effective if they meet users' requirements and expectations. In line with this, this investigation aims to answer the second part of the fifth question of the dissertation (RQ5b), "*Does the actual PHA meet the UX design requirements for its acceptance by the target audience?*" To answer this question, I requested the potential participants in the pilot study to evaluate the app in terms of the six UX design and adoption-related constructs: *perceived aesthetics*, *perceived usability*, *perceived credibility*, *perceived usefulness*, *perceived persuasiveness* and *intention to use*. The measurement instruments and the demographics of the study participants are the same with those of S4a. I adopted an exploratory approach to investigate the research question and how both cultures significantly differ, although some hypotheses can be formulated. For example, the target users are more likely to perceive the intervention versions (PV and SV) better than the control version (CV) in terms of all six UX design constructs.

8.5.2 Results

In this section, I present the culture-specific mean ratings of the six UX design constructs, and a three-way analysis of variance (ANOVA) based on the culture of the user, version of the app and PTAM construct. The three-way ANOVA employed the Aligned Rank Transform for Non-parametric Factorial Analyses [75], which was based on the "ARTool" package in R [76]. Prior to the ANOVA, I conducted a McDonald's omega (ω) reliability test for each multi-item construct. The reliability test, which was based on the "ci.reliability" function in R's "MBESS" library [191], showed that each construct met the requirement: $\omega \geq 0.7$ [172].

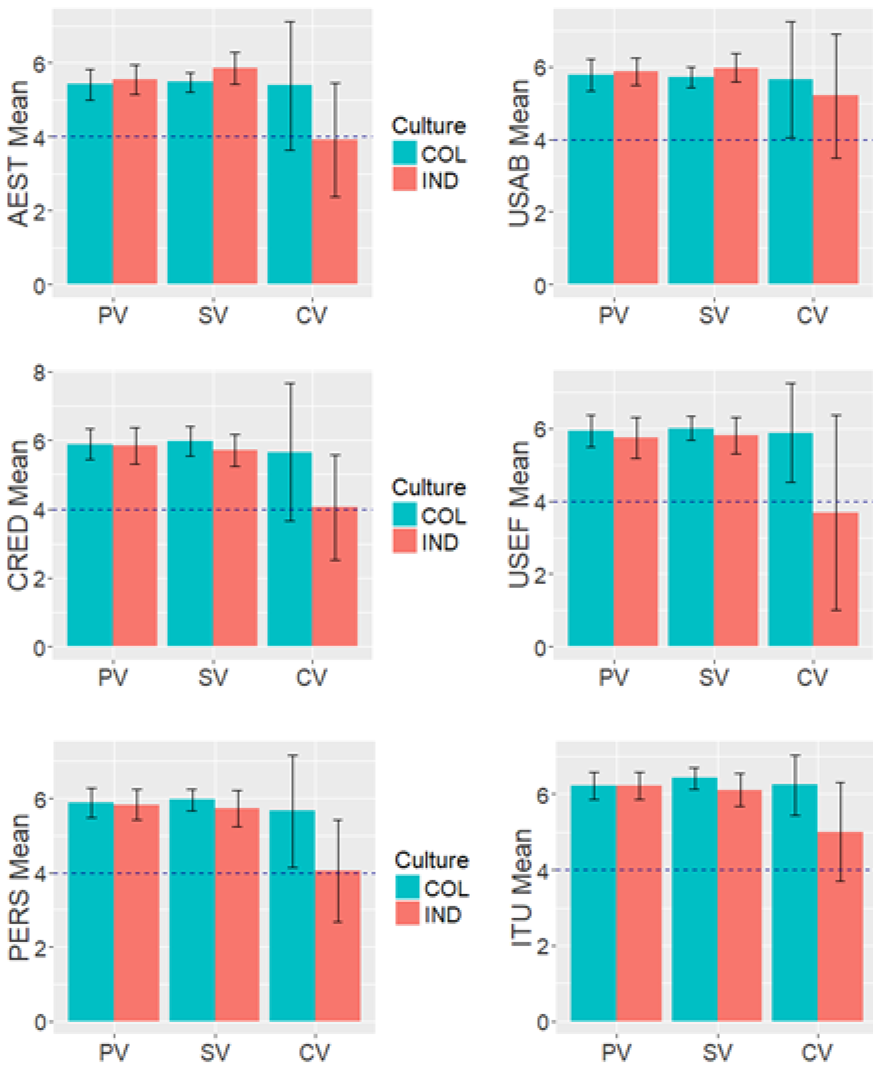

Figure 8.8: Mean rating of the perceived UX design constructs for an actual PHA. Vertical bar = 95% confidence interval. Crossbar = neural value on a 7-point Likert scale. AEST = Perceived Aesthetics, USAB = Perceived Usability, CRED = Perceived Credibility, USEF = Perceived Usefulness, PERS = Perceived Persuasiveness, ITU = Intention to Use. PV = Personal Version, SV = Social Version, CV = Control Version.

Averaging Rating of the PTAM Constructs

Prior to conducting the ANOVA, I computed and plotted the mean ratings of the PTAM constructs (UX design attributes, *perceived persuasiveness* and *intention to use*) as shown in Figure 8.8. Overall, regardless of culture, the study participants rated all six constructs regarding each version of the app above the neutral value of 4. The only exceptions are with regard to the CV version, in which the individualist participants rated its *perceived aesthetics* and *perceived usefulness* less than 4, and its *perceived credibility* and *perceived persuasiveness* approximately 4.

Three-Way ANOVA based on Culture, App Version and PTAM Construct

Table 8.12 shows the significant results of the three-way ANOVA. There are two main effects: app version effect [$F_{2,486} = 15.52$, $p < 0.001$, $\eta_p^2 = 0.06$] with a medium effect size and PTAM construct effect [$F_{5,486} = 4.55$, $p < 0.001$, $\eta_p^2 = 0.04$] with a small effect size. Moreover, there is an interaction between culture and version [$F_{2,486} = 7.02$, $p < 0.001$, $\eta_p^2 = 0.03$] with a small effect size.

Table 8.12: Main effect and interaction analysis based on culture, app version and PTAM construct based on an actual PHA. DF = degree of freedom, DF.Res = residual degree of freedom. $\eta_p^2 = 0.01$: small effect size, $\eta_p^2 = 0.06$: medium effect size, $\eta_p^2 = 0.14$: large effect size [193][195].

	Culture	**App Version**	**PTAM Construct**	**Culture × Version**
DF.Res	486	486	486	486
DF	1	2	5	2
F-Value	1.32	15.52	4.55	7.02
p-Value	$p = n.s$	$p < 0.000$	$p < 0.001$	$p < 0.001$
η_p^2-Value	0.00	0.06	0.04	0.03

Main Effect of App Version

Table 8.13 shows the posthoc pairwise comparisons between the app versions. The results show that there is no effect of app version in the PV-SV comparison ($p = n.s$). However, there is a significant effect of app version in the PV-CV and SV-CV comparisons ($p < 0.001$), with a medium effect size ($d \geq 0.50$). Specifically, PV (M = 5.78) and SV (M = 5.89) is significantly rated higher than the CV version (M = 5.05). However, as shown in Table 8.12, there is an interaction between culture and app version (see Table 8.15), indicating the significant difference between PV and CV as well as between SV and CV depends on culture.

Main Effect of PTAM Construct

Table 8.14 shows the posthoc pairwise comparisons among the PTAM constructs. The results show the comparisons are not significant, except the comparison between *intention to use* and *perceived aesthetics/perceived credibility* ($p < 0.05$), with a medium effect size. Specifically, the study participants rated *intention to use* (M = 6.21) significantly higher than *perceived aesthetics* (M = 5.47) and *perceived credibility* (M = 5.55).

Table 8.13: Posthoc pairwise comparison of the overall average scores of the perceived UX design constructs for each version of the actual PHA. $d = 0.01$: very small effect size, $d = 0.20$: small effect size, $d = 0.50$: mediun effect size, $d = 0.80$: large effect size, $d = 1.20$: very large effect size, $d = 2.0$: huge effect size [195].

Comparison	Mean 1	Mean 2	p-Value	d
PV-SV	5.78	5.89	$p = n.s$	0.11
PV-CV	5.78	5.05	$p < 0.001$	0.77
SV-CV	5.89	5.05	$p < 0.001$	0.88

Table 8.14: Posthoc pairwise comparison of the average scores of the perceived UX design constructs of the actual PHA. $d = 0.01$: very small effect size, $d = 0.20$: small effect size, $d = 0.50$: mediun effect size, $d = 0.80$: large effect size, $d = 1.20$: very large effect size, $d = 2.0$: huge effect size [195].

Comparison	Mean 1	Mean 2	p-Value	d
Aesthetics–Usability	5.47	5.78	$p = 0.42$	0.37
Aesthetics–Credibility	5.47	5.55	$p = 0.99$	0.11
Aesthetics–Usefulness	5.47	5.78	$p = 0.201$	0.46
Aesthetics–Persuasiveness	5.47	5.77	$p = 0.484$	0.36
Aesthetics–Intention to Use	5.47	6.21	$p < 0.001$	0.86
Usability–Credibility	5.78	5.55	$p = 0.79$	0.26
Usability–Usefulness	5.78	5.78	$p = 1.00$	0.09
Usability–Persuasiveness	5.78	5.77	$p = 1.000$	0.02
Usability–Intention to Use	5.78	6.21	$p = 0.14$	0.49
Credibility–Usefulness	5.55	5.78	$p = 0.52$	0.34
Credibility–Persuasiveness	5.55	5.77	$p = 0.83$	0.24
Credibility–Intention to Use	5.55	6.21	$p < 0.05$	0.75
Usefulness–Persuasiveness	5.78	5.77	$p = 1.00$	0.10
Usefulness–Intention to Use	5.78	6.21	$p = 0.32$	0.41
Persuasiveness–Intention to Use	5.77	6.21	$p = 0.11$	0.51

Interaction between Culture and App Version

Table 8.15 shows the one-way ANOVA at each level of culture and app version. The results show that, regarding the PV and SV versions, there is no effect of culture. However, regarding the CV version, there is an effect of culture [$F_{1,46} = 16.24$, $p < 0.001$, $\eta_p^2 = 0.26$] with a large effect size. Moreover, within the collectivist culture, there is no effect of app version [$F_{2,315} = 0.74$, $p = n.s$]. However, within the individualist culture, there is a significant effect of app version [$F_{2,201} = 18.45$, $p < 0.000$, $\eta_p^2 = 0.16$]. Owing to the effect of app version within the individualist culture, I conducted a posthoc pairwise comparison among the three versions of the app. The results (Table 8.15) show that there is a significant difference between the PV and CV versions as well as between the SV and CV versions ($p < 0.001$), with a very large effect size ($d \geq 1.20$).

Table 8.15: Further one-way analysis of variance at each level of culture and PHA version. $\eta_p^2 = 0.01$: small effect size, $\eta_p^2 = 0.06$: medium effect size, $\eta_p^2 = 0.14$: large effect size [193][195]. $d = 0.01$: very small effect size, $d = 0.20$: small effect size, $d = 0.50$: mediun effect size, $d = 0.80$: large effect size, $d = 1.20$: very large effect size, $d = 2.0$: huge effect size [195].

		One-way ANOVA for each App Version			
		PV	SV	CV	Version Effect
One-way ANOVA within each Culture	COL	5.78	5.88	5.68	$F_{2,315} = 0.74$, $p = n.s, \epsilon^2 = 0.00$
	IND	5.78	5.87	4.43	$F_{2,201} = 18.45$, $p < 0.000$, $\eta_p^2 = 0.16$
	Culture Effect	$F_{1,214} = 0.32$, $p = n.s$, $\eta_p^2 = 0.00$	$F_{1,256} = 0.00$, $p = n.s$, $\eta_p^2 = 0.00$	$F_{1,46} = 16.24$, $p < 0.001$, $\eta_p^2 = 0.26$	
Posthoc Pairwise Comparison		PV-SV	PV-CV	SV-CV	
	COL	$p = n.s$	$p = n.s$	$p = n.s$	
	IND	$p = n.s$, $d = 0.14$	$p < 0.001$, $d = 1.22$	$p < 0.001$, $d = 1.37$	

8.5.3 Discussion

In this investigation, I presented the results of a three-way ANOVA on the mean values of the perceived UX design constructs of an actual PHA. The results showed that there is an interaction between culture and app version, and a main effect of app version and PTAM construct. Figure 8.8 shows that, regardless of the intervention app version (PV and SV) and culture, the study participants rated all six PTAM constructs higher than 5 on a 7-point scale. This is an indication of the participants' satisfaction with the intervention app UX designs. The rating of all of the six UX design constructs above 5 can be attributed to the relationships between them. Recall, among the UX design constructs in the PTAM, *perceived aesthetics* is the most distal. As such, it is one of the first ports of call when users first come in contact with a human-computer-interaction (HCI) artifact. Hence, in the evaluation of the PHA, the participants' high rating of *perceived aesthetics* might have influenced the high rating of the other UX design constructs. For example, the mean score of *perceived aesthetics* is relatively high (M > 5), so also are the mean scores of *perceived usability*, *perceived credibility*, *perceived usefulness*, *perceived persuasiveness* and *intention to use*. In particular, the apparent influence of *perceived aesthetics* on the other UX design constructs is evident in the individualist participants' mean ratings of the CV version of the PHA. As shown in Figure 8.8, their mean rating of the *perceived aesthetics* of the CV version is less than that of the PV and SV versions. This relatively lower rating of *perceived aesthetics* by the individualist participants might have influenced the lower rating of the other UX design constructs, especially *perceived credibility*, *perceived usefulness* and *perceived persuasiveness*, which mean ratings are approximately or below the neutral value of 4.

Moreover, as shown in Table 8.13, the participants perceived the UX design of the PV (M = 5.78) and SV (M = 5.89) versions better than the CV version (M = 5.05). With a medium to a large effect size, the mean difference in the respective ratings suggests that that the participants viewed the PV and SV versions as more *aesthetic*, *usable*, *credible*, *useful*, *persuasive* and thus had a higher *intention to use* them than the CV version. However, the three-way ANOVA (Table 8.12) showed that there is an interaction between app version and culture with a small effect size. A further one-way ANOVA at each level of culture (Table 8.15) showed that, in the collectivist group, there is no significant difference between the average ratings of each pair of the three app versions. However, in the individualist group, while there is no significant difference between PV and SV in the mean ratings, there is between PV and CV, and between SV and CV, both of which have a very large effect size. These findings suggest that the individualist group perceived the PV/SV versions as more *aesthetic*, *usable*, *credible*, *useful* and *persuasive* than the CV version, which is not the case for the collectivist group. One plausible explanation for this finding is that, in general, individualist users are more likely to be critical of HCI artifacts than collectivist users [119]. As a result, as shown in Table 8.15, the individualist participants rated the CV version less favorably than the collectivist participants, with the mean difference having a small effect size.

Finally, as shown in Table 8.14, the participants rated their *intention to use* the PHA ($M = 6.21$) higher than the other UX design constructs ($M < 6$). In particular, the mean difference between *intention to use* and *perceived aesthetics*/*perceived credibility* is significant with a medium to large effect size. One plausible explanation why the *intention to use* the PHA is rate numerically and/or significantly higher than the other constructs is the participants' eagerness to pilot the app. This is more evident in the individualist group's ratings of the CV version of the app. Despite its relatively lower rating of the *perceived aesthetics*, *perceived credibility*, *perceived usefulness* and *perceived persuasiveness* of the CV version ($M \leq 4$), the individualist group had a relatively high *intention to use* it ($M = 5$) to motivate their behavior change in the field.

8.5.4 Summary of Findings

In conclusion, I summarize the main findings of the current investigation (S4b) as follows:

(a) The individualist and collectivist cultures do no significantly differ in their overall ratings of the UX design constructs of the intervention versions of the PHA (PV and SV).

(b) The individualist culture viewed the CV version of the PHA less favorably than the collectivist culture in terms of the perceived levels of the UX design constructs.

(c) Regardless of culture, the study participants perceived the PV and SV versions of the PHA as *aesthetic*, *usable*, *credible*, *useful* and *persuasive*.

(d) Regardless of culture, the study participants had a high *intention to use* the three versions of the PHA.

Based on the above findings, I provide an answer to the main research question of this investigation (RQ5b), "*Does the actual PHA meet the UX design requirements for its acceptance by the target audience?*" Given that the rating of each of the UX design constructs (especially *perceived aesthetics* and *perceived* *usefulness*) is approximately 6/7, I can conclude that the intervention versions of the PHA (PV and SV) meet the UX design requirements of the target users. This indicates that the potential users are likely to adopt them to motivate their behavior change in the field. Specifically, among the individualist participants, the intervention versions are more likely to be adopted than the control version (CV) in motivating behavior change in the field. The next chapter on the app evaluation will help to validate or refute these hypotheses.

8.6 Conclusion and Contributions

In this chapter, I presented two investigations (S4a and S4b) prior to the target audience piloting the three versions of the implemented PHA (PV, SV and CV) in the field. S4a is concerned with uncovering the strongest perceived UX design determinants of the target audience's *intention to use* the PHA in the field and the moderating effect of culture. Moreover, S4b is concerned with uncovering the perception profile of the target audience with regard to the UX design attributes of the PHA and the moderating effect of culture. In S4a, I found that, regardless of culture, *perceived aesthetics* and *perceived usefulness* are the strongest UX design determinants of the *intention to use* a PHA such as a fitness application. Specifically, in the individualist culture, *perceived persuasiveness* mediates the effect of *perceived usefulness* on intention to use. However, this is not the case in the collectivist culture. The main contribution of this investigation is that it replicates the major findings in S3a: beauty (*perceived aesthetics*) and utility (*perceived usefulness*) are the strongest determinants of the *intention to use* a PHA. In S4b, I found that, regardless of culture, the target audience perceived the three versions of the PHA as aesthetic, usable, credible, useful and persuasive ($M > 4$). The only exception is that the individualist culture did not perceive the CV version as aesthetic and useful ($M < 4$). They barely perceived it as persuasive and credible as well ($M \approx 4$). That notwithstanding, both cultures had a high positive *intention to use* ($M > 5$) the three versions of the PHA in the field.

8.7 Limitations

The main limitation of S4 is that the measurements of the UX design attributes and the *intention to use* the PHA are subjective. In other words, they are based on the study participants' perceptions and not the *actual use* of the PHA. The second limitation of the study concerns the sample size in relation to the maximum number of links pointing at a given construct in the path model. Based on the 10-times rule of thumb, the sample size required to build a path model should be greater than 10 times the maximum number of links pointing at any endogenous construct in the inner model [72]. In the PTAM shown in Figure 8.3, the maximum number of links pointing at a construct (*perceived persuasiveness*) is four. Given that the small sample size of the participants that took part in the pre-evaluation of the PHA ($n = 87$), this requirement was only met for the collectivist group ($n = 53$), but not for the individualist group ($n = 34$). That said, the 10-times rule of thumb is nearly met ($n = 37$ instead of 40) for the individualist culture, as the sample size is only short of three data points.

9 Evaluation of Culture-Tailored Persuasive Health Application in the Field

This chapter focuses on the sixth step of the EMVE-DeCK Framework, which is the evaluation of the effectiveness of the culture-tailored persuasive health application (PHA) in the field. Figure 9.1 shows its situation in the EMVE-DeCK Framework. The evaluation of the PHA (called BEN'FIT) represents the "change" stage of the framework. In this intervention stage, I conducted an investigation (S5) to examine the *overall* and *culture-tailoring* effectiveness of an actual PHA in the field. Moreover, this chapter discusses the validation and refinement of the prior social cognitive theory (SCT) based PT design guidelines (from S1) in the light of new experimental findings from S5.

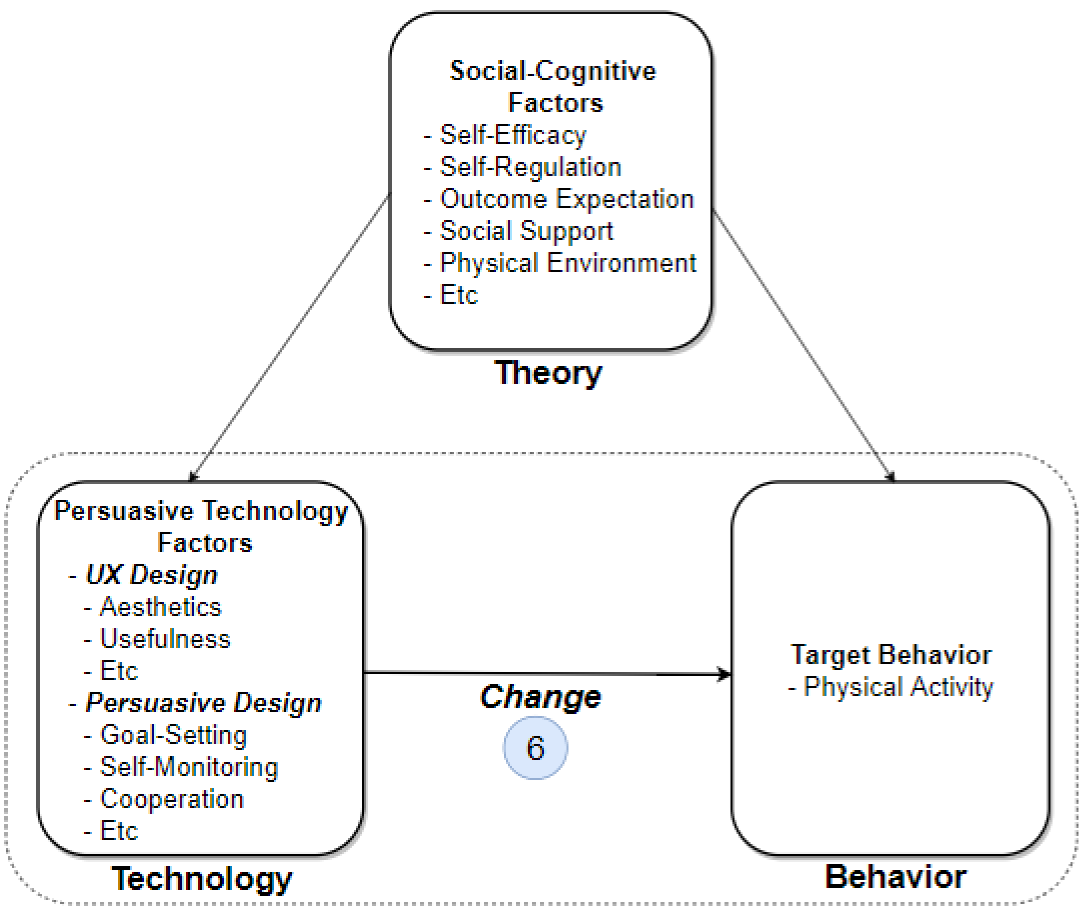

Figure 9.1: Situating the evaluation of the PT intervention in the EMVE-DeCK Framework

9.1 Motivation

Most existing persuasive technologies (PTs) in the health domain lack a theoretical basis for evaluating their effectiveness in the field [271][272]. Furthermore, the effectiveness of culture-tailoring has been understudied in a field setting. In particular, among the African populations, there is little to no in-the-field PT research [22], especially in the area of physical activity, which is a global problem affecting all people, regardless of culture, race, gender, age and income status. As a result, the current study sets out to investigate the potential effectiveness of using theory and culture to tailor a PHA to the individualist and collectivist populations using Canada/America and Nigeria, respectively as a case study.

9.2 Related Work

A number of studies have been conducted in the field to evaluate PT interventions aimed at promoting physical activity. Thorsteinsen et al. [273] investigated the effectiveness of a PT intervention in a three-month trial among 21 participants. The app employed short message service (SMS), a calendar for planning physical activities, monitoring progress, feedback and gamification components. The authors found that the intervention group performed significantly better than the control group. The main limitations of the study are that it focused on a traditional persuasive technique (text messaging) only, did not employ theory or look at the effect of culture. Further, Consolvo et al. [274] employed Presentation of Self in Everyday Life [275] and Cognitive Dissonance [276] theories to develop and evaluate an intervention they called UbiFit Garden. They found that the intervention was effective in promoting physical activity over a three-month period. However, the study only focused on the individualist culture (United States participants). Brindal et al. [277] developed and evaluated a texting-based mobile app to promote weight loss. They found in their eight-week trial among 58 participants that the intervention was more effective than the control version. However, the authors only focused on women. Secondly, their app design was not based on a behavior theory. Moreover, Brindal et al. [278] designed and evaluated a theory-based mobile app called MotiMate to assist people in maintaining weight loss. The app employed user-tailored feedback, motivational messages and other persuasive strategies to motivate behavior change. In a 24-week trial among 88 participants, the authors found few observable effects of the intervention on the target behavioral outcomes compared with the control version (basic tracker). One of the main limitations of the intervention is that it was designed based on theoretical persuasive features (e.g., behavioral prompts) drawn from the literature and not the target user model grounded in behavior theories, e.g., SCT, Health Belief Model, etc. This limitation may be partially responsible for the few observable effects of the intervention.

The sampled work is representative of most existing PT interventions for encouraging physical activity. Their major limitation is that did not employ theory in their app design, as Monteiro et al. [272] found in a recent systematic review of mobile apps promoting physical activity. Moreover, the studies did not consider the effect of culture. Rather, they focused on individualist populations (e.g., [102], [278], [274]).

9.3 S5: Investigation of the Overall and Culture-Tailoring Effectiveness of Actual Persuasive Health Application in the Field

This investigation (S5) examines the overall and culture-tailoring effectiveness of the intervention app—personal version (PV) and social version (SV)—in comparison with the control version (CV). The first objective of the investigation is to uncover empirical evidence that shows that a health application equipped with persuasive features (PV or SV) is more likely to motivate behavior change compared with a health application unequipped with persuasive features (CV). The second objective is to uncover empirical evidence that demonstrates that a tailored version of a PHA is more likely to be effective than a contra-tailored version.

9.3.1 Research Questions

Formally, the investigation aims to answer the sixth research question of this dissertation (RQ6), "***How can we evaluate the effectiveness of an actual PHA in the field?***." This research question is broken down into the following two subquestions:

> RQ6a. Is the actual health application equipped with persuasive features more likely to be effective in motivating the physical-activity behavior of the target audience than the unequipped?
>
> RQ6b. Is the tailored PHA more likely to be effective in motivating the physical-activity behavior of the target audience than the untailored?

9.3.2 Study Method

To answer the research questions, I recruited participants from the collectivist and individualist cultures to evaluate the three versions of the PHA in a pilot study in the field. Thereafter, I had the selected/validated participants use the three versions for a staggered four-week period between May and August 2019. Prior to conducting the study, it was submitted to the University of Saskatchewan Behavioral Research Ethics Board for review and approval. See the participants' consent forms in Appendix G for the study approval number.

Study Design

The intervention study employed a mixed-method approach to answer the two subquestions. The quantitative approach objectively measured the participants' actual PAL over a four-week period. The qualitative approach was based on the feedback provided to the researcher while using the PHA and the chat messages among the participants that used the SV version of the app. To examine the overall effectiveness of the culture-tailored PHA, the PV and SV versions of BEN'FIT were compared against the CV version. Moreover, to measure the effectiveness of culture-based tailoring, the tailored version of the PHA was compared with the contra-tailored version within each culture.

Participants

Among the 202 participants that expressed interest in participating in the evaluation of the PHA, about 185 of them were invited to download the app and take part in piloting the health intervention. These participants reported that they were mostly non-gym goers and were not currently using a fitness app to support their exercise at the time of the intervention. Among the 185 participants, 70 downloaded the app. Table 9.1 shows the percentages of participants in each culture who actually used each version of the app among those who downloaded the app and registered to use it. Overall, 70 participants downloaded the app and registered to pilot it. However, only 59 of them were validated to be part of the data analysis. A higher percentage of participants dropped out of the CV version (28.57%) compared with the percentage that dropped out of the PV version (11.54%) and SV (13.33%) version. Participants in each version was randomly assigned, regardless of the version of the app (PV or SV) they had chosen at the pre-selection stage. Each of the participants was compensated with CAD $1 for each of the days they used the app in the four-week period. Table 10.11 shows the demographics of the 59 valid participants after data cleaning: 35 of them are collectivist participants from Nigeria and 24 are individualist participants from Canada/United States.

Table 9.1: Percentage of participants who used the actual PHA among the signed-up participants. Churners are those who downloaded the app, installed it on their phone, signed up to pilot the app but never used it to log their physical activities. OVR = Overall Population.

	Registrants			**Churners**			**App Users**			**% App Users**		
Version	**COL**	**IND**	**OVR**	**COL**	**IND**	**OVR**	**COL**	**IND**	**OVR**	**COL**	**IND**	**OVR**
PV	18	8	26	3	0	3	15	8	23	83.33	100.00	88.46
SV	16	14	30	2	2	4	14	12	26	87.50	85.71	86.67
CV	7	7	14	1	3	4	6	4	10	85.71	57.14	71.43
Total	41	29	70	6	5	11	35	24	59	85.37	82.76	84.29

Table 9.2: Demographics of intervention participants who evaluated the actual PHA in the field

		Number			**Percent**		
Criterion	**Subgroup**	**COL**	**IND**	**OVERALL**	**COL**	**IND**	**OVERALL**
Gender	Female	13	13	26	37.1	54.2	44.1
	Male	22	11	33	62.9	45.8	55.9
	18-24	9	6	15	25.7	25.0	25.4
Age	25-34	21	9	30	60.0	37.5	50.8
	35-44	4	7	11	11.4	29.2	18.6
	45-54	1	2	3	2.9	8.3	5.1
	Canada	21	0	21	0.0	87.5	35.6
Country of Origin	United States	3	0	3	0.0	12.5	5.1
	Nigeria	0	35	35	100.0	0.0	59.3
	PV	15	8	23	42.9	33.3	39.0
App Version	SV	14	12	26	40.0	50.0	44.1
	CV	6	4	10	17.1	16.7	16.9

Measurement Instruments

Apart from objectively measuring the study participants' actual PAL over a four-week period, I asked them to provide feedback to the researcher by using the interface shown in Figure 7.17. Altogether, five measures were used in evaluating the overall and culture-tailoring effectiveness of the PHA. They include the following:

1. **Churn Rate (CR):** The percentage of users who installed each version of the app but did not use it to track their exercise during the four-week period;
2. **Physical Activity Level (PAL):** The average user's total MET-mins/week for each app version;
3. **Physical Activity Status (PAS):** The percentage of users who were active on the average ($\geq$ 600 MET-mins/week) for each version of the app;
4. **Feedback Rate (FBR):** The percentage of users that provided feedback to the researcher/developer for each version of the app; and
5. **Peer-to-Peer Engagement (PPE):** The percentage of users who used the in-built chat app in the SV version of the app.

Research Hypotheses

In general, research [21][61] shows that PTs (apps intentionally designed to change behavior by being equipped with persuasive features) are more likely to be effective than those not intentionally designed to change behavior. Recall that, in S4b (see Chapter 8), I found that the PV and SV versions were perceived as more persuasive (in terms of the overall UX design) than the CV version, especially among the individualist group. As such, in the light of the first research question (RQ6a), I hypothesize as follows:

H1. The PV version of the PHA will be more effective than the CV version.

H2. The SV version of the PHA will be more effective than the CV version.

Secondly, research [26][32] shows that PHAs are more likely to be effective if they are tailored to the target audience. Recall that, in the theory domain, in S1a (Chapter 4), I found that personal factors (Self-Efficacy and Self-Regulation) and social factors (Social Support) are the strongest drivers of Physical Activity in the individualist and collectivist cultures, respectively. I replicated these findings in the application domain. Quantitatively, in S2a (Chapter 5), based on the ranking metric, I found that individualist users are more likely to be receptive to Goal-Setting/Self-Monitoring. In contrast, based on the rating and ranking metrics, I found that collectivist users are more likely to be receptive to Cooperation and Social Learning. Moreover, qualitatively, in S3 (Chapter 6), I found that the individualist participants (48%) made more favorable comments about Goal-Setting/Self-Monitoring than the collectivist participants (28%). In contrast, the collectivist participants (32%) made more favorable comments about Cooperation than the individualist participants (20%). Finally, in S3d (Chapter 6), I found that over 50% of the individualist participants requested the Goal-Setting/Self-Monitoring feature compared with 25% of the collectivist participants. In contrast, 28% of the collectivist participants requested the Reminder/Notification feature compared with 4% of the individualist participants. Hence, regarding the second subquestion (RQ6b), I hypothesize as follows:

H3. The PV version will be more effective than the SV version for the individualist culture.

H4. The SV version will be more effective than the PV version for the collectivist culture.

H5. The PV version will be more effective for the individualist culture than for the collectivist culture.

H6. The SV version will be more effective for the collectivist culture than for the individualist culture.

H3 and H5 investigate the comparative effectiveness of PV within and between cultures, respectively. Similarly, H4 and H6 investigate the comparative effectiveness of SV within and between cultures, respectively.

9.3.3 Results

The effectiveness of the intervention and culture-based tailoring was measured using the five metrics presented in the previous section CR, PAL, PAS, FBR and PPE. I present the results based on each metric.

Churn Rate (CR)

Churn rate is defined as the number of users that dropped out of the study after installing and registering to use the app. It is a concept mostly used in online business to describe the number of registered customers a company, e.g., Amazon, loses over a period of time. Figure 9.2 shows the churn rate in each version of the PHA. More individualist participants dropped out of the CV and PV versions than collectivist participants. Moreover, the cultural difference in the SV drop-outs is not large. Overall, the highest percentage of drop-outs is in the CV version (28.6%), followed by the SV version (13.3%) and the PV version (11.5%).

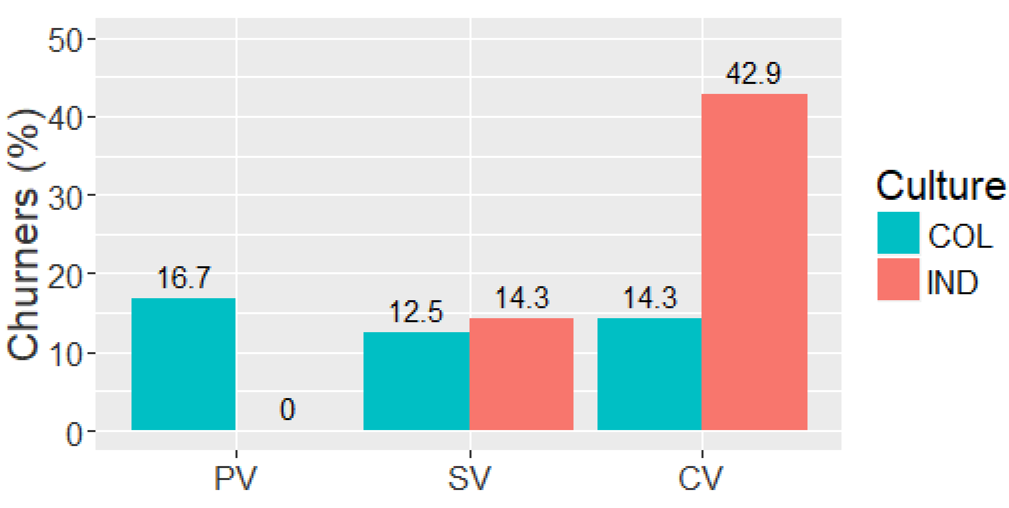

Figure 9.2: Percentage of participants that did not use the app over the four-week period

Average Physical Activity Level (PAL) Per Week over Four-Week Period

Two types of activity were engaged in by the participants: bodyweight exercise (e.g., push-up, squat, etc.) and walking (step count). The summation of both types of activity gives the total PAL/week. Figure 9.3 shows all three types of activity in MET-mins/week for both cultures with regard to each version of the app.

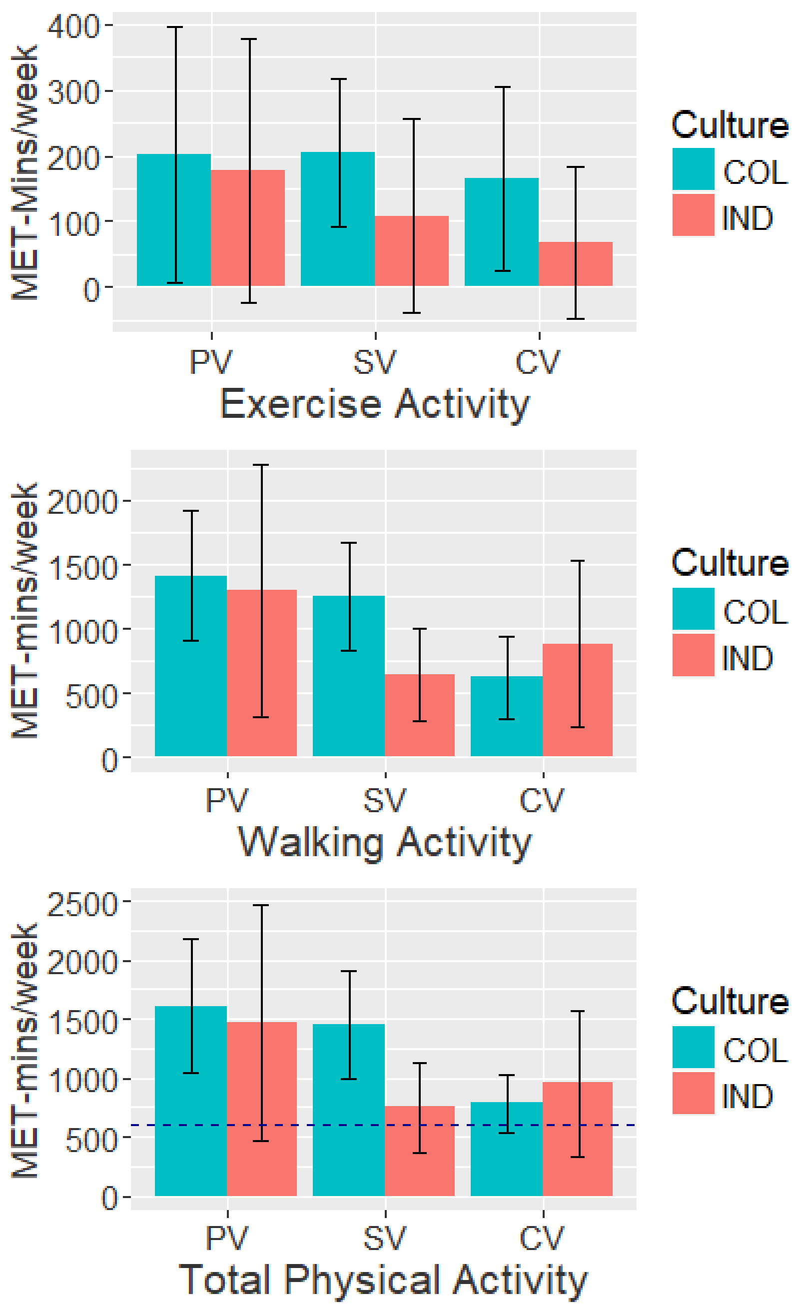

Figure 9.3: Participants' average exercise, walking and total physical activity level per week over a four-week period. The vertical bar represents confidence interval; the crossbar represents the WHO-recommended minimum PAL per week (600 MET-mins/week) required for an individual to be active.

Regarding exercise, the average PAL of the collectivist participants who used the SV version (204.52 MET-mins/week) and PV version (201.72 MET-mins/week) is the highest, while the PAL of the individualist participants who used the CV version (68.00 MET-mins/week) is the lowest, followed by the PAL of individualist participants who used the SV version (108.41 MET-mins/week).

Regarding walking, the average PALs of the collectivist participants (1409.24 MET-mins/week) and individualist participants (1295.00 MET-mins/week) who used the PV version of the app are the highest. On the other hand, the PALs of the collectivist participants who used the CV version (622.27 MET-mins/week) and individualist participants who used the SV version (642.20 MET-mins/week) are the lowest.

Finally, regarding the total physical activity, the average PALs of the collectivist participants (1610.96 MET-mins/week) and individualist participants (1471.74 MET-mins/week) who used the PV version are the highest, followed by the PAL of the collectivist participants (1457.77 MET-mins/week) who used the SV version. On the other hand, the PAL of the individualist participants (750.60 MET-mins/week) who used the SV version of the app is the lowest, followed by the PAL of the collectivist participants (786.08 MET-mins/week) and individualist participants (952.15 MET-mins/week) who used the CV version.

Three-Way Analysis of Variance of Average PAL/Week. Table 9.3 shows the result of a three-way ANOVA based on the version of the app (PV, SV and CV), type of activity the user engaged in (walking and exercise) and the culture of the user (collectivist and individualist). There are three main effects (version, activity and culture) and three fully significant interactions ($p < 0.05$), each of which is between two of the factors. The activity main effect is the strongest [$F_{1,106} = 84.81$, $p < 0.000$, $\eta_p^2 = 0.44$] with a large effect size, followed by the culture effect [$F_{1,106} = 9.66$, $p < 0.01$, $\eta_p^2 = 0.08$] with a medium effect size. The version effect is the least strong main effect [$F_{2,106} = 5.01$, $p < 0.01$, $\eta_p^2 = 0.09$] with a medium effect size.

Table 9.3: Main effects and interactions in three-way ANOVA between app version, user culture and activity type. "×" indicates interaction between two factors; DF = degree of freedom; DF.Res = residual degree of freedom. η_p^2 = partial eta squared representing effect size. $\eta_p^2 = 0.01$: small effect size, $\eta_p^2 = 0.06$: medium effect size, $\eta_p^2 = 0.14$: large effect size [193][195].

Factor	**DF**	**DF.Res**	***F*-Value**	***p*-Value**	**η_p^2-Value**
Activity	1	106	84.81	0.0000	0.44
Culture	1	106	9.66	0.0024	0.08
Version	2	106	5.01	0.0083	0.09
Activity × Culture	1	106	5.13	0.0256	0.05
Activity × Version	2	106	3.35	0.0388	0.06
Culture × Version	2	106	3.28	0.0414	0.06
Activity × Culture × Version	2	106	3.00	0.0541	0.05

The strongest interaction is between activity and culture [$F_{1,106} = 5.13$, $p < 0.05$, $\eta_p^2 = 0.05$] with a near medium effect size, followed by the interaction between activity and version [$F_{2,106} = 3.35$, $p < 0.05$, $\eta_p^2 = 0.06$] with a medium effect size. The least strong interaction is between culture and version [$F_{1,1653} = 3.28$, $p < 0.05$, $\eta_p^2 = 0.06$] with a medium effect size. Moreover, the result of the three-way ANOVA shows there is a marginal interaction between the three factors [$F_{2,106} = 3.00$, $p = 0.0541$, $\eta_p^2 = 0.05$], with a medium effect size. However, given that the significance of the two-factor interactions, further one-way ANOVAs at each level of each factor involved in the interaction were carried out as a follow-up.

Main Effect of Version of App on Participants' PAL/Week. Figure 9.4 shows the total PAL/week for the three versions of the app. Due to the main effect of app version, I carried out a post-hoc pairwise comparison. Table 9.4 shows the results of the pairwise comparisons among the three versions. There is a significant difference between PV and SV ($p < 0.0476$, $d = 0.50$) and between PV and CV ($p < 0.0133$, $d = 0.79$), but none between SV and CV ($p = 0.5136$, $d = 0.30$), though the former is numerically higher.

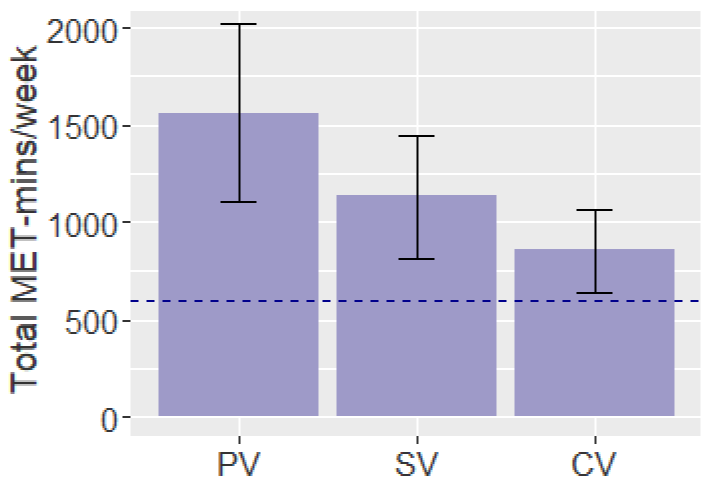

Figure 9.4: Participants' average total PAL/week in each version of the app. The crossbar represents the WHO-recommended minimum PAL (600 MET-mins/week) required for an individual to be active.

Table 9.4: Pairwise comparisons of participants' total MET-mins/week between app versions. $d = 0.20$: small effect size, $d = 0.50$: mediun effect size, $d = 0.80$: large effect size [195].

Version	PV	SV	CV
Total MET-mins/week	1562.54	1131.38	852.50
Comparison	PV-SV	PV-CV	SV-CV
***p*-Value**	0.0476	0.0133	0.5136
***d*-Value**	0.50	0.79	0.30

Main Effect of Culture on Participants' PAL/Week. Figure 9.5 shows the total PAL/week for the two types of culture. The pairwise comparison results show that, overall, without considering the version of the app and type of activity users engaged in, the collectivist group (1408.28 MET-mins/week) is significantly more active ($p < 0.05$) than the individualist group (1024.57 MET-mins/week). However, the three-way ANOVA shows that there is an interaction between culture and version and between culture and activity.

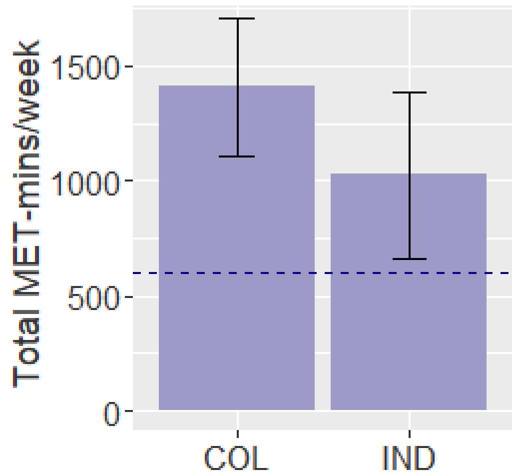

Figure 9.5: Participants' average total PAL/week in each culture. The crossbar represents the WHO-recommended minimum PAL (600 MET-mins/week) required for an individual to be active.

Main Effect of Activity on Participants' PAL/Week. Figure 9.6 shows the total PAL/week for the two types of activity. The pairwise comparison result shows that, overall, without considering the version of the app and the culture of the user, the participants' walking activity (1085.10 MET-mins/week) is significantly higher ($p < 0.0001$) than their exercise activity (167.10 MET-mins/week). However, the three-way ANOVA shows that there is an interaction between activity and culture and between activity and version.

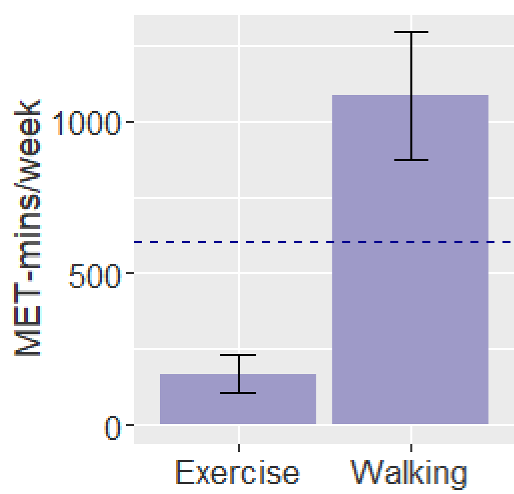

Figure 9.6: Participants' average total PAL/week in each activity. The crossbar represents the WHO-recommended minimum PAL (600 MET-mins/week) required for an individual to be active.

Interaction between Activity and Culture of User. Due to the interaction between activity and culture, I conducted a further one-way ANOVA at each level of both factors. Table 9.5 shows the results of the analysis. Within each culture, there is an effect of activity, with a large effect size: collectivist culture [$F_{1,68} = 95.52, p < 0.000$, $\eta_p^2 = 0.58$] and individualist culture [$F_{1,46} = 50.93$, $p < 0.000$, $\eta_p^2 = 0.53$]. However, there is no effect of culture in each type of activity, although there is a marginal effect of culture on walking [$F_{1,57} = 3.52$, $p = 0.066$, $\eta_p^2 = 0.06$].

Table 9.5: Further one-way analysis of variance at each level of culture and activity. $\eta_p^2 = 0.01$: small effect size, $\eta_p^2 = 0.06$: medium effect size, $\eta_p^2 = 0.14$: large effect size [193][195].

	One-way ANOVA within each Activity			
		Exercise	Walking	Activity Effect
One-way ANOVA within each Culture	COL	196.34	1211.93	$F_{1,68} = 95.52$, $p < 0.000$, $\eta_p^2 = 0.58$
	IND	124.45	900.12	$F_{1,46} = 50.93$, $p < 0.000$, $\eta_p^2 = 0.53$
	Culture Effect	$F_{1,57} = 2.27$, $p = 0.138$, $\eta_p^2 = 0.04$	$F_{1,57} = 3.52$, $p = 0.066$, $\eta_p^2 = 0.06$	

Interaction between Activity of User and Version of App. Though our three-way ANOVA showed that there is an interaction between activity and version, a further one-way ANOVA based on each level of activity and each level of version shows there is no interaction as shown in Table 9.6. There is a simple effect of activity in each version, with a large effect size ($\eta_p^2 \geq 0.50$). Remarkably, the effect is in the same direction. In other words, the average walking MET-mins/week is significantly higher than the average exercise MET-mins/week for all three versions ($p < 0.000$), indicating there is no interaction. Similarly, Table 9.6 shows that there is no simple effect of version for each type of activity, also indicating there is no interaction.

Table 9.6: Further one-way analysis of variance at each level of activity and app version. $\eta_p^2 = 0.01$: small effect size, $\eta_p^2 = 0.06$: medium effect size, $\eta_p^2 = 0.14$: large effect size [193][195].

	One-way ANOVA within each Version				
		PV	SV	CV	Version Effect
One-way ANOVA within each Activity	Exercise	193.04	160.16	125.49	$F_{2,56} = 0.02$, $p < 0.98$
	Walking	1369.50	971.23	727.02	$F_{2,56} = 1.86$, $p = 0.17$
	Activity Effect	$F_{44,1} = 57.13$, $p < 0.000$, $\eta_p^2 = 0.56$	$F_{1,50} = 50.79$, $p = 0.000$, $\eta_p^2 = 0.51$	$F_{1,18} = 25.13$, $p < 0.000$, $\eta_p^2 = 0.58$	

Interaction between Culture of User and Version of App. As a result of the interaction between the culture of the user and the version of the app, I conducted a further one-way ANOVA at each level of both factors. as shown in Table 9.7. The result of the analysis shows there is no significant effect of version at each level of culture. However, there is a significant effect of culture for those participants that used the SV version of the app [$F_{1,50} = 4.79, p < 0.05$, $\epsilon^2 = 0.09$] with a medium effect size. Specifically, among the users of the SV version of the app, the total PAL/week of collectivist participants (1457.77 MET-mins/week) are significantly higher ($p < 0.05$) than the total PAL/week of the individualist participants (750.60 MET-mins/week).

Table 9.7: Further one-way analysis of variance at each level of culture and app version. ϵ^2 = effect size. $\epsilon^2 = 0.01$: small effect size, $\epsilon^2 = 0.08$: medium effect size, $\epsilon^2 = 0.26$: large effect size [194].

		One-way ANOVA within each Culture			
		PV	SV	CV	Version Effect
One-way ANOVA within each Version	COL	805.48	728.88	393.04	$F_{2,67} = 0.43$, $p = 0.65$
	IND	735.87	375.30	476.07	$F_{2,45} = 0.93$, $p = 0.40$
	Culture Effect	$F_{1,44} = 0.05$, $p = 0.82$, $\epsilon^2 = 0.00$	$F_{1,50} = 4.79$, $p < 0.05$, $\epsilon^2 = 0.09$	$F_{1,18} = 0.012$, $p < 0.91$, $\epsilon^2 = 0.00$	

Average Physical Activity Status over Four-Week Period

In addition to the participants' average PAL/week, I uncovered the percentage of participants in each version whose average PAL/week equals and/or is above 600 MET-mins/week, which is the WHO-recommended PAL/week for an individual to be (moderately) active. Figure 9.7 shows the percentage of participants in each version of the app who met the recommendation. The collectivist and individualist participants who used the SV version of the app recorded the highest percentage (92.9%) and lowest percentage (50%), respectively, of active participants in the pilot study.

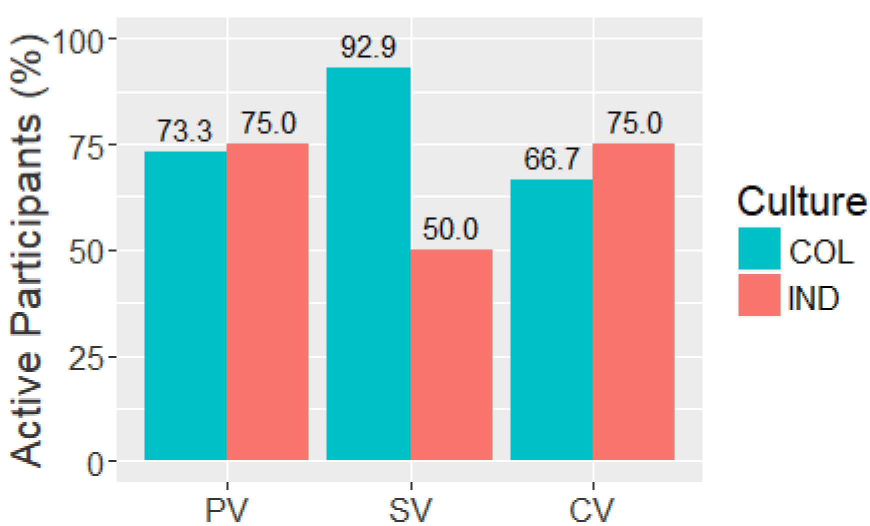

Figure 9.7: Percentage of active participants based on the average total PAL/week. Active level ≥ 600 MET-mins/week.

Feedback Rate over Four-Week Period

Table 9.8 shows the percentage of participants who provided feedback with regard to each intervention version of the app. Regarding the PV version, a higher percentage of individualist participants (75%) provided feedback to the researcher/developer than the percentage of collectivist participants (46.67%). In contrast, regarding the SV version, a higher percentage of collectivist participants (64.29%) provided feedback to the researcher/developer than the percentage of individualist participants (25%).

Table 9.8: Percentage of participants who provided feedback (FB) in each intervention version

Version	Culture	Valid App Users	FB Users	%FB Users	Total #FB	Av. #FB/User
PV	COL	15	7	46.67	39	5.57
	IND	8	6	75.00	42	7.00
SV	COL	14	9	64.29	56	6.22
	IND	12	3	25.00	52	17.33
	Total	59	25	42.37	189	7.56

Peer-to-Peer Engagement among SV Participants

Aside from looking at the participants' average PAL and PAS per week, I investigated the percentage of participants in each culture who used the chat feature built into the SV version of the app and analyzed their peer-to-peer (P2P) engagement. This analysis is aimed at uncovering the culture that used the SV version in a more engaging way and understanding how peers in each culture engaged with each other. Table 9.9 shows the summary information about user engagement with each other while using the SV version of the app.

Table 9.9: Percentage of SV participants in each culture who used the chat app. #Days is the period (range of days) peers were involved in chatting; #Turns is the number of turn-takings in the P2P chat; #Sentences in each P2P chat; #Peers is the number of participants involved in each P2P chat; #SV Users is the number of SV participants that are retained after the quantitative data cleaning; #Valid Peers is the percentage of SV participants in each culture that are involved in P2P chat. "*" indicates one of the peers in the group was excluded from the quantitative analysis after data cleaning.

ID	#Days	#Turns	#Sentences	#Peers	#Valid Peers	#SV Users	%Active Peers
CG1	20	6	15	2	2	-	-
CG2	4	6	9	2	2	-	-
CG3	4	8	11	2	2	-	-
CG4*	16	1	3	1	1	-	-
CG5*	13	5	5	2	1	-	-
CG6	14	13	27	2	2	-	-
CG7	4	7	10	2	2	-	-
COL	**75**	**46**	**80**	**13**	**12**	**14**	**86.67**
IG1	3	2	2	2	2	-	-
IND	**3**	**2**	**2**	**2**	**2**	**12**	**16.67**

Overall, peers in the collectivist culture (12/14, 86.67%) engaged with each other via the chat app more than peers in the individualist culture (2/12, i.e., 16.67%). The results show that more participants in the collectivist culture (12/14, 86.67%) engaged in a P2P conversations than in the individualist culture (2/12, i.e., 16.67%). Of the 8 two-person groups that used the SV version of the app in the collectivist culture, 7 of them (CG1-CG7) used the chat app. However, only one of the 7 two-person groups that used the SV version of the app in the individualist culture (IG1) used the chat app. Moreover, over 40 turn-takings between peers were involved in the collectivist P2P chats (by CG1-CG7), compared with only 2 turn-takings in the individualist P2P chat (by IG1). Thus, more conversations were engaged in by the collectivist peers (over 80 sentences) than the individualist peers (2 sentences).

In summary, 86.67% of the 14 valid collectivist participants (involved in the quantitative analysis) engaged with their peers while using the SV version of the app compared with 16.67% of the 12 valid individualist participants. This suggests that a collaborative app that allows users to cooperate is more likely to effective in changing behavior among collectivist users than individualist users. Table 9.11, Table 9.10 and Table 9.12 show the P2P conversations for CG6, CG1 and IG1, respectively.

Table 9.10: Conversation between collectivist group (CG1) peers over the four-week period

Message of Peer 1 [P26]	**Message of Peer 2 [P25]**
`Hi Partner`	
	`Hello`
	`My name is [Name of P25], what is your name ?`
`[Name of P26], hope you had a good day`	
	`Are you based in Nigeria?`
	`yea, I sure did.`
	`hope you're doing good.. how has the exercise been?`
`Yes, I live in Lagos, Nigeria`	
`the exercise have been quite interesting, the body aches have reduced and I'm able to stay longer on activities`	
	`oh good to know. The aches were quite much at the beginning.`
`where are you from?`	
	`I live in Lagos also`
`hope the app is helping you as much as it's helping me`	
	`yeah, it actually is, helps me be consistent`
`cool`	
`Well done`	

Table 9.11: Conversation between collectivist group (CG6) peers over the four-week period

Message of Peer 1 [P47]	**Message of Peer 2 [P45]**
how do we start with this app	
	Hi
I guess you're my partner for this exercise	
	Sure
	My name is [First Name]
Okay	
what targets Should we set for the week	
	Am thinking that we should burn [X] Cal per week. what do you think?
that's too low	
	okay. what's your suggestion
2000 at least	
I'm actually on 1500	
	that's nice
	would that be enough to burn [X] calory?
that's 1500cal	
it's more than [X] already	
you haven't been performing activities	
[Partner's Name] are you there	
maybe you should drop your WhatsApp number so I could show you how to complete an activity because I can see your steps are being counted but no records of any activity completed by you	
	was a little sick
	[********** - Mobile #]
	Tnx
	I tried starting today.
Good	
you work on mturk?	
are you there	

Table 9.12: Conversation between Individualist group (IG1) peers over the four-week period

Message of Peer 1 [P19]	**Message of Peer 2 [P9]**
Hello	
	Hey! Sorry didn't see this till now

9.3.4 Discussion

In this section, I discuss the validation of the hypotheses of the investigation and the implications for PHA design.

Validation of Hypotheses

Table 9.13 shows a summary of the main findings with regard to the six hypotheses and two new findings that are not based on prior hypotheses. Overall, all of the hypotheses are validated on the basis of at least one of the five metrics: CR, PAL, PAS, FBR and PPE. In this section, I discuss the validation of the hypotheses and the new findings.

Table 9.13: Summary of findings based on the evaluation of culture-tailored PHA in the field. CR = Churn Rate, PAL = Physical Activity Level, PAS = Physical Activity Status, FBR = Feedback Rate, PPE = Peer-to-Peer Engagement. Superscript[1] denotes the hypothesis based on PAS is only validated for the collectivist culture.

No.	Hypothesis and New Finding	Metric	Remark
H1	The PV version of the PHA will be more effective than the CV version of the PHA.	CR, PAL	✓
H2	The SV version of the PHA will be more effective than the CV version of the PHA.	CR, PAS[1]	✓
H3	The PV version of the PHA will be more effective than the SV version for the individualist culture.	CR, PAS, FBR	✓
H4	The SV version of the PHA will be more effective than the PV version for the collectivist culture.	PAS, FBR	✓
H5	The PV version of the PHA will be more effective for the individualist culture than for the collectivist culture.	CR, FBR	✓
H6	The SV version of the PHA will be more effective for the collectivist culture than for the individualist culture.	PAL, PAS, FBR, PPE	✓
F7	Collectivist users are more likely to engage in physical activity (especially walking) than individualist users.	PAL	✓
F8	Users, regardless of culture, are more likely to engage in walking than engage in exercise.	PAL	✓

Validation of the First Hypothesis (H1). The result of the data analysis shows that there is a different churn rate among the users of the three versions of the app. The churn rate result (Figure 9.2) shows that the highest percentage of dropouts was among individualist participants who used the CV version of the app. 42.9% of them dropped out of the study (i.e., did not use the app). The second highest percentage of dropouts was among collectivist participants who used the PV version of the app. 16.7% of them dropped out of the study. The lowest percentage of dropouts was among individualist participants who used the PV version of the app, 0% of whom dropped out of the study. The second lowest percentage of dropouts was among collectivist participants who used the SV version of the app, 12.5% of whom dropped out of the study. Overall, the largest percentage of dropouts is among the CV group (28.6%), followed by the SV group 13.3% and the PV group (11.5%). Based on these findings, in terms of churn rate, without considering culture, the PV and SV versions are the most effective, while the CV version is the least effective. This finding suggests that a health application equipped with persuasive features such as Goal-Setting/Self-Monitoring (in a personal setting) or Cooperation in concert with group-based Goal-Setting/Self-Monitoring (in a social setting) is more likely to be effective in motivating behavior change than the one unequipped with persuasive features. Thus, based on the CR metric, the first hypothesis (H1), "*The PV version of the app will be more effective than the CV version of the app*," is supported. Moreover, based on the PAL metric, the posthoc pairwise comparisons, regarding the effect of app version, show that participants who used the PV version are significantly ($p < 0.01$) more active (1562.54 MET-mins/week) than those who used the CV version (565.69 MET-mins/week) with a medium effect size (see Table 9.3). Thus, again, based on the PAL/week metric, the first hypothesis (H1), "*The PV version of the app will be more effective than the CV version of the app*," is validated.

Validation of the Second Hypothesis (H2). Based on the PAL metric, although the average PAL/week of the SV participants (1131.38 MET-mins/week) is numerically higher than that of the CV participants (565.69 MET-mins/week), the posthoc pairwise comparisons showed that the participants who used the SV version are not significantly ($p = n.s$) more active than those who used the CV version. The plausible explanation for this non-significant difference is that the individualist group did not do well in the SV version compared with their performance in the PV version and with the collectivist group's performance in the SV version. However, based on the average PAS/week metric, a higher percentage of the collectivist participants who used the SV version of the app (92.9%) were active than the percentage of the collectivist participants who used the CV version (66.7%). Thus, based on the PAS metric, for the collectivist culture, in particular, the second hypothesis (H2), "*The SV version of the app will be more effective than the CV version of the app*," is validated. Moreover, based on the CR metric, as shown in Figure 9.2, a higher percentage of CV participants (28.57%) dropped out of the intervention compared with the percentage of SV participants (13.33). This is more evident in the individualist culture than in the collectivist culture. In particular, 42.9% of the individualist CV participants dropped out of the intervention compared with 14.3% of the individualist SV participants who dropped out. Thus, overall (based on this CR-based finding and the initial PAS-based finding for the collectivist culture), the second hypothesis (H2), "*The SV version of the app will be more effective than the CV version of the app*," is validated.

Validation of the Third Hypothesis (H3). Based on the PAL metric, although the average PAL/week of the individualist PV participants (1471.74 MET-mins/week) is numerically higher than that of the SV participants (750.60 MET-mins/week), the interaction between culture and version (Table 10.12) did not confirm it. However, based on the PAS-based metric, the percentage of individualist participants that used the PV version who were active (75%) is higher than the percentage of individualist participants that used the SV version who were active (50%). Secondly, based on the FBR metric (Table 9.8), the percentage of individualist PV participants who provided feedback (75%) to the researcher/developer is higher than the percentage of the individualist SV participants who provided feedback (25%). An example of feedback provided by an individualist PV participant [P1] is, "*The results of the last few days has not been typical. I have been away from home and traveling. Back home today.*" This participant was providing feedback on the reason behind not being able to exercise at the time because he had been away from home. On the other hand, an example of feedback from an individualist SV participant is, "*Feeling better after doing it longer. Going to try and go for 20 minutes tomorrow*" [P15, IND]. This participant was providing feedback on the positive impact of physical activity on him. Thirdly, based on the CR metric (Figure 9.2), the percentage of individualist PV participants who dropped out of the intervention (0%) is less than the percentage of the individualist SV participants who dropped out (14.3%). Therefore, based on the PAS-, FBR- and CR-based findings, the third hypothesis (H3), "*The PV version of the app will be more effective than the SV version for the individualist culture*," is validated.

Validation of the Fourth Hypothesis (H4). Based on the PAS metric, the percentage of collectivist participants that used the SV version who were active (92.9%) is higher than the percentage of collectivist participants that used the PV version who were active (73.3%). Moreover, based on the FBR metric (Table 9.8), the percentage of collectivist SV participants who provided feedback (64.29%) to the researcher/developer is higher than the percentage of the collectivist PV participants who provided feedback (46.67%). An example of feedback provided by a collectivist SV participant (P42) is, "*nice workout it's really strengthening my knees.*" Another example of similar feedback from a collectivist PV participant (P38) is, "*Seeing some changes in my physical fitness.*" Therefore, based on the PAS and FBR metrics, the fourth hypothesis (H4), "*The SV version of the app will be more effective than the PV version for the collectivist culture*," is validated.

Validation of the Fifth Hypothesis (H5). Based on the PAL and PAS metrics, the differences between the collectivist and individualist groups are not significant and substantial, respectively. However, based on the CR metric (Figure 9.2), the percentage of individualist PV participants who dropped out of the intervention (0%) is less than the percentage of the collectivist PV participants who dropped out (16.7%). Moreover, based on the FBR metric (Table 9.8), there is a higher percentage of individualist PV participants (75%) than the percentage of collectivist PV participants (46%) who provided feedback to the researcher. Therefore, based on the CR and FBR metrics, the fifth hypothesis (H5), "*The PV version of the app will be more effective for the individualist culture than for the collectivist culture*," is validated.

Validation of the Sixth Hypothesis (H6). Regarding the interaction between culture and version, the further one-way ANOVA at each app version level, shows that both cultures do not significantly differ regarding the PV and CV version; however, they do significantly differ regarding the SV version [$F_{1,50} = 4.79$, $p < 0.05$, $\eta_p^2 = 0.09$] with a medium effect size. The collectivist participants have a higher average PAL/week

(728.88 MET-mins/week) than the individualist participants (375.30 MET-mins/week). This means, in terms of total PAL/week, the collectivist group (1457.52 MET-mins/week) that used the SV version has a higher PAL/week than the individualist group (750.60 MET-mins/week). Secondly, the PAS result (Figure 9.7) shows that there are some differences between the collectivist and individualist cultures and between users of the PV and SV versions. Specifically, both cultures differ in their activity status in the SV version. There is a higher percentage of active collectivist SV participants (92.9%) than the percentage of active individualist SV participants (50%). This finding confirms the PAL-based finding. Thirdly, based on the FBR metric (Table 9.8), there is a higher percentage of collectivist SV participants (64.29%) than the percentage of individualist SV participants (25%) who provided feedback to the researcher/developer of the app.

Fourthly, the PPE result (Table 9.9) shows that more participants in the collectivist culture (86.67%) engaged in a P2P conversations than in the individualist culture (16.67%). Of the 8 two-person groups that registered to used the SV version of the app in the collectivist culture, 7 of them (CG1-CG7) used the chat app. However, only one of the 7 two-person groups that used the SV version of the app in the individualist culture (IG1) used the chat app. Moreover, over 40 turn-takings between peers were involved in the collectivist P2P chats (by CG1-CG7), compared with only 2 turn-takings in the individualist P2P chat (by IG1). Thus, more conversations were engaged in by the collectivist peers (over 80 sentences) than the individualist peers (2 sentences). In summary, 86.67% of the 14 valid collectivist participants (involved in the quantitative analysis) engaged with their peers while using the SV version of the app compared with 16.67% of the 12 valid individualist participants. This suggests that the collaborative app that allow users to cooperate is more likely to effective in changing behavior among collectivist users than individualist users. Thus, based on the PAL, PAS, FBR and PPE metrics, the sixth hypothesis (H6), "*The SV version of the app will be more effective for the collectivist culture than for the individualist culture*," is validated.

Other Main Findings

The three-way ANOVA showed that, there is a main effect of culture, activity and version, with a near medium to large effect size (Table 9.3). Regarding the effect of culture (with a medium effect size), the collectivist group (1408.28 MET-mins/week) significantly engaged in more physical activity than the individualist group (1024.57 MET-mins/week), with the larger part of the total difference being accounted for by the difference in walking MET-mins/week (i.e., step count). This result may not be surprising given that, in an individualist society such as Canada/United States (a high-income developed countries), there is less active transportation systems as a result of individuals owning personal cars and well-organized, more reliable institution-driven transportation systems (e.g., bus transits), which enable people to commute to and from their destinations easily. As such, it is more likely that individuals in the collectivist culture (such as Nigeria – a low-to-middle-income developing country) would walk more compared with those in the individualist culture. Particularly, regarding the walking activity, the one-way ANOVA shows that there is a marginal effect of culture [$F_{1,57} = 3.52$, $p = 0.066$, $\eta_p^2 = 0.06$]. The walking PAL/week of the collectivist participants (1211.93 MET-mins/week) is nearly significantly higher than the walking PAL/week of the individualist participants (900.12 MET-mins/week) by over 300 MET-mins/week.

Regarding the effect of activity (with a large effect size), the study participants are more likely to engage in walking than bodyweight exercise, regardless of culture. For the collectivist group, the walking PAL/week (1211.93 MET-mins/week) is significantly higher [$F_{1,68} = 95.52$, $p < 0.000$] than the exercise PAL/week (196.34 MET-mins/week). Similarly, for the individualist group, the walking PAL/week (900.12 MET-mins/week) is significantly higher [$F_{1,46} = 50.93$, $p < 0.000$] than the exercise PAL/week (124.45 MET-mins/week). These main effects of activity at the cultural level are consistent with the overall main effect of activity on participants' PAL/week in the three-way ANOVA. It is noteworthy that the supposed interaction between activity and culture did not manifest at each level of activity and culture, perhaps due to the smaller sample size as a result of splitting the data at each level. Already, we have seen that the walking MET-mins/week is significantly higher than the exercise MET-mins/week regardless of culture. Moreover, regarding exercise activity, the one-way ANOVA shows that there is no effect of culture [$F_{1,57} = 2.27$, $p = 0.138$]. This means that the collectivist participants (196.34 MET-mins/week) and the individualist participants (124.45 MET-mins/week) do not significantly differ ($p > 0.05$). Thus, based on the overall effect of activity, it can be concluded that, regardless of culture, users are more likely to engage in walking than exercise.

Peer-to-Peer Engagement among SV Participants

Overall, as shown in Table 9.9, the collectivist participants, who used the SV version of the PHA, engaged with each other using the chat app more than the individualist participants. At least six collectivist groups (Table 9.10), compared with only one individualist group (Table 9.11), engaged in P2P conversations while using the PHA to motivate their behavior change in the field. The conversations between the collectivist peers include: (1) personal introduction and familiarization, (2) knowing where one's partner live, (3) negotiating goals, (4) inquiring about how one's partner is progressing with the exercise, and (5) knowing the challenges one's partner is facing. For example, in CG1 group conversation (Table 9.10), P25 asked P26, "*Are you based in Nigeria . . . hope you're doing good.. how has the exercise been?*" P26 replied, respectively, "*Yes, I live in Lagos, Nigeria . . . the exercise have been quite interesting, the body aches have reduced and I'm able to stay longer on activities.*" Moreover, in CG6 conversation, a joint goal was negotiated between P47 and P45. P47 asked, "*what targets Should we set for the week [?]*" P45 replied, "*Am thinking that we should burn [X] Cal per week. what do you think?*" To this reply, P47 responded, "*that's too low . . . 2000 at least.*" In the same conversation, we see P47 ask for P45's mobile number (which was provided) so that he could call P45 if the latter did not respond to his chat messages early enough. On the other hand, there was only two messages between members of the only individualist group that used the chat app. P19 sent P60 a message, "*hello.*" P9 responded two days later, "*Hey! Sorry didn't see this till now.*" And that was all. Again, these chat-based results provide qualitative evidence that confirms the sixth hypothesis (H6) that states, "*The SV version of the app will be more effective for the collectivist culture than for the individualist culture.*"

Explanation for Why the SV Version is Less Effective in the Individualist Culture

Among the individualist participants, a number of reasons must have been responsible for the SV version of the PHA being less effective than the PV version and than among the collectivist participants. Those reasons, which can be regarded as demotivators, can be found in S2c (Table 5.22). The most relevant ones are revisited by way of explaining the current findings arising from the evaluation of the PHA in the field.

Health Data Privacy and Confidentiality. In the application domain, one plausible explanation for why users in the individualist group are less likely to perform well in the SV version than in the PV version and than users in the collectivist group, is the ever-increasing concern about privacy and confidentiality in the West. Prior research [33] revealed that members of individualist cultures are greatly concerned with the privacy and confidentiality of their health data. In S2c, this concern is evident in the individualist participants' unwillingness to use the social features of a PHA, which may require the viewing of their health information by other users such as their partners. Table 5.23 down to Table 5.35 show a cross-section of the negative comments from the individualist participants on Cooperation, Social Learning and Social Comparison features, which attest to the lower rating and ranking of these social features less than the neutral value of 4 and mean value of 3.5, respectively, by the individualist participants in S2a. For example, in the individualist culture, four of the participants remarked about the Cooperation feature thus: (1) "*Again, I'm not one to share my goals*" [P10, IND]; (2) "*I don't want others gossiping about my activity level!*" [P13, IND]; (3) "*i dont like interacting with other people on apps. I dont like other people seeing what Im doing on apps*" [P40, IND]; and (4) "*I hate this feature. I dont need people knowing my information*" [P49, IND].

Dislike for Reliance and/or Dependence on Others with regard to Health Goals and Rewards. A second plausible explanation for why users in the individualist culture are less likely to perform well in the SV version than in the PV version and than users in the collectivist culture is that they do not want to rely on others in creating their health goals and earning rewards. This is the sixth weakness (SW6) of social features in S2c (Table 5.28). Users in the individualist culture want to have the capacity to act independently and make autonomous decisions. They do not want their behavior and its outcome to be influenced by or dependent on others. For example, in S3c, the following are four of the individualist participants' comments about the Cooperation feature, which attest to the dislike they have for social reliance and dependence on others: (1) "*I don't really [want] my performance to be connected to another person's and vice versa*" [P44, IND]; (2) "*I dont like that my points depend an another persons activity*" [P52, IND]; (3) "*Wouldn't want to depend on someone else*" [P160, IND]; and (4) "*I don't care for this because I would be irritated at having someone else try to push me along*" [P64, IND].

Lack of Familiar Partner. A third plausible explanation for why users in the individualist culture are less likely to perform well using the SV version than the PV version and than users in the collectivist culture is that they lack familiar collaborative partners (e.g., family and friends). For example, in S2c, four of the individualist participants remarked about the Cooperation feature thus: (1) "*I don't know other people*"

[P70, IND]; (2) "*I don't have a lot of contacts that use apps for health and well-being, so I would probably never achieve my group goals*" [P139, IND]; (3) "*Same as before, I don't think I could convince anyone to use the app with me*" [P138, IND]; and (4) "*My family and friends are not very active so I probably would not participate with them*" [P150, IND].

Belief that Exercise is a Personal Activity. A fourth plausible explanation for why users in the individualist culture are less likely to perform well using the SV version than the PV version and than users in the collectivist culture is that they view exercise as a personal activity. In line with this notion, four of the participants in the individualist culture in S3c remarked about the Cooperation feature thus: (1) "*It doesn't seem like something that would really be helpful since exercise to me is more of an independent activity*" [P156, IND]; (2) "*It [exercise] should be individualized*" [P136, IND]; (3) "*I'm not one to work with others on personal goals so this wouldn't have much influence over me*" [P48, IND]; and (4) "*As stated earlier physical activity is something I would rather not share with others*" [P146, IND].

Dislike for Working Together as a Group or Team. A fifth plausible explanation for why users in the individualist culture are less likely to perform well using the SV version than the PV version and users in the collectivist culture is that they do not enjoy or like working with others. For example, in line with this notion, four individualist participants remarked about the Cooperation feature thus: (1) "*I hate working with others*" [P128, IND]; (2) "*I dont know- i just do not enjoy this part of the app. im a 'do it yourself person'*" [P109, IND]; (3) "*i dont like interacting with other people on apps...*" [P40, IND]; and (4) "*I prefer to work out alone to clear my head*" [P127, IND].

Dislike for Social Comparison. A sixth plausible explanation for why users in the individualist culture are less likely to perform well using the SV version than the PV version and than users in the collectivist culture is that they do not like comparing themselves with others. For example, three of the individualist participants remarked about the Cooperation feature thus: (1) "*I would not wish to compare myself to others*" [P133, IND]; (2) "*Don't want to compare myself and would not want to rely on someone else*" [P135, IND]; and (3) "*I would not want to compare goals*" [P87, IND].

Dislike for Social Pressure. A seventh plausible explanation for why users in the individualist culture are less likely to perform well in the SV version than in the PV version and than users in the collectivist culture is that they do not like social pressure as it causes stress. As a result, the individualist users tend to shy away from taking advantage of the power of social influence, e.g., Social Comparison, to motivate their physical activity. For example, four of the individualist participants in S3c remarked about the Cooperation feature thus: (1) "*While the group goal setting is unique and interesting, I personally would not use an app with this feature. The social pressure to reach that goal would only increase my stress level*" [P104, IND]; (2) "*I don't care for this sort of pressure, but it would probably be effective with certain people*" [P24, IND]; (3) "*I feel this would be too much pressure to perform*" [P120, IND]; and (4) "*I don't like being responsible for other people's success or failure in achieving goals too much pressure*" [P155, IND].

Averse to Socially Engendered Guilt and Shame. An eighth plausible explanation for why users in the individualist culture are less likely to perform well in the SV version than in the PV version and than users in the collectivist culture is that they are averse to the sense of guilt and shame poor exercise performance may cause. While this reason may be a motivator for certain people, it is a demotivator for some of the individualist participants. For example, one of the individualist participants in S3c remarked about the Cooperation feature thus, "*This seems very guilt based, which is an important motivator for some but I would hate it.*" [P159, IND].

Indifferrence to Others' Physical Activity. A ninth plausible explanation for why users in the individualist culture are less likely to perform well in the SV version than in the PV version and than users in the collectivist culture is that they are indifferent about others' physical activity. As a result, they may not be receptive to the Cooperation and Social Learning features implemented in the SV version of the app and the Social Comparison both social features engender. For example, in S2c, four of the participants in the individualist culture remarked about the Cooperation feature thus: (1) "*I don't care how others do*" [P147, IND]; (2) "*I wouldn't really care about other people*" [P153, IND]; (3) "*I control my diet and exercise and have no interest in what someone else is doing for theirs.*" [P165, IND]; and (4) "*I don't exercise with friend or keep track of my friends exercising therefore this feature isn't important to me*" [P163, IND].

Motivating Individualist Users to Adopt Social PHAs

To improve the chances of individualist users adopting and using Cooperation-based PHAs to drive their physical-activity behavior, the identified demotivators should be mitigated, if possible. First, individualist users should be allowed to use social PHAs anonymously, Second, individualist users should be allowed to choose whom to collaborate with. This might result in individualist users picking collaborative partners whom they are familiar with and can share their physical activity and progress with. Third, to mitigate individualist users' demotivation in a social setting, they should be encouraged to collaborate with people with similar physical abilities and skill sets. This will reduce the chances of one partner not measuring up and the guilt and shame it might bring.

9.4 Validation/Refinement of SCT-Based PT Design Guidelines based on Experimental Findings in the Application Domain

In recent time, there have been calls for mixed-method research that supports triangulation between quantitative and qualitative findings to provide more reliable cross-verified findings [279]. Particularly, there is a need to triangulate perception-based and field studies to uncover how empirical findings based on self-reports generalize to the field setting. Consequently, this section is aimed to answer the seventh research question (RQ7), "***Do the social-cognitive determinants of physical-activity behavior in the theory domain (based on self-report) generalize to the application domain?***," and providing PT design guidelines.

Based on the quantitative and qualitative findings from S1, S2 and S5, the answer to above research question is "yes." In the SCT-based study (S1), I proposed a number of culture-specific persuasive strategies which users from both cultures may be receptive to and provided PT design guidelines for their implementation in the application domain. The persuasive strategies were mapped from the culture-specific social-cognitive determinants of physical-activity behavior in the theory domain. Specifically, for the individualist culture, Self-Efficacy and Self-Regulation were mapped to Goal-Setting, Self-Monitoring, Reward, etc. On the other hand, for the collectivist culture, Social Support was mapped to Cooperation, Social Comparison, Social Learning, etc. Moreover, in the storyboard-based study (S2) and field study (S5), I validated the SCT-based findings in each culture. In addition, in both studies, I found that collectivist users are likely to be receptive to personal as well as social strategies. Second, I uncovered key supportive/persuasive features users from both cultures care about. To synthesize all of the findings in this dissertation, I present: (1) a set of refined PT design guidelines, (2) statistical data and sample participants' comments from S2 to support the guidelines, and (3) a brief implementation of the guidelines when necessary.

Guideline #1: Allow users to set goal and monitor their progress [Goal-Setting/Self-Monitoring]

Users should be allowed to set goals and monitor their progress over time. Regardless of culture, Goal-Setting/Self-Monitoring is the most persuasive feature users are receptive to. In S3d, for example, 26% of the collectivist participants and 53% of the individualist participants requested Goal-Setting and Self-Monitoring. Both features combined offer the following benefits: (1) help and motivate users to engage in exercise behavior; (2) help users to set and track health goals and progress; (3) provide motivational (visual) feedback that drives users to reach their goals; (4) help users to adjust their exercise behavior to reach their goals; (5) help to keep users focused on their plans and health goals; and (6) make users accountable. Regarding Goal-Setting, tailored goals (e.g., WHO-recommended MET-mins/week presented as calories burned per week) should be suggested and pre-set to prevent users from having to figure out the ideal goal and entering it themselves. Some users view entering goals manually as tedious. For example, in S2b, P116 remarked that goal-setting "*seems like a good thing to do, but I think I would just skip the step if I had to change it daily.*" Similarly, P181 commented that it "*would require far too much time to input [goal] accurately.*" In a personal setting, Goal-Setting/Self-Monitoring is more likely to be effective in the individualist culture, while, in a social setting, it is more likely to be effective in the collectivist culture.

Guideline #2: Reward users for the achievement of their goals [Reward]

Users should be rewarded for achieving their goals and reaching milestones (e.g., with points, badges, etc.). Apart from having something to work and strive for as a form of motivation, users like and enjoy being rewarded for their achievements. For example, in S2b, P32 commented that "*I like getting rewarded for hitting milestones.*" Moreover, P53 remarked, "*I would enjoy getting rewards when meeting my goals and the app would be relevant in this way.*" Overall, especially based on the thematic analysis of the participants' comments in S2b, collectivist users are more likely to be receptive to Reward than individualist users. For example, while 35% of the individualist participants made unfavorable comments about Reward, only 11% of the collectivist participants did. Moreover, a higher percentage of the collectivist participants (40%) made favorable comments about Reward than the percentage of the individualist participants (35%). One plausible explanation for why individualist users are less receptive to the Reward feature is that the rewards offered in the Reward storyboard in S2b are virtual. Hence, they prefer that they be converted into tangible things that have real-life value. For example, P49 (an individualist participant) remarked that "*[t]he points are worthless to me unless they can be exchanged for real world goodies.*"

Guideline #3: Allow users to cooperate with one another [Cooperation]

Users should be given the opportunity to work together to achieve joint goals. Particularly, users in the collectivist culture, like and enjoy collaboration, even though their partners may be strangers. For example, in S2c, 32% of the collectivist participants made favorable comments about Cooperation compared with 20% of the individualist participants. On the other hand, only 4% of the collectivist participants made unfavorable comments about Cooperation compared with 38% of the individualist participants. Cooperation is likely to be effective for a number of reasons. Firstly, Cooperation motivates and challenges users to work harder. Secondly, users find Cooperation interesting, which provides them with fun. Thirdly, users do not want to be the reason for the failure of their group. Fourthly, Cooperation fosters accountability among collaborative partners. Specifically, it provides collectivist users with the opportunity to make new friends, know and encourage one another to achieve their individual goals as a part of a collective goal. As such, Cooperation is more likely to be effective in the collectivist culture than in the individualist culture. For example, in S3c, collectivist participants such as P193, P215 and P245 commented that "*I like to work in team,*" "*I enjoy team work*" and "*I like teamwork,*" respectively. In contrast, a good number of individualist users view physical activity as personal. As such, they do not like working with others in a group and/or relying on others for the achievement of their goals and rewards. For example, individualist participants such as P128 and P140 commented that "*I hate working with others*" and *I don't like team work,*" respectively. One main reason why a number of individualist users do not like working with others is privacy and confidentiality. As such, Cooperation is more likely to be effective among individualist users when they are allowed to work with people whom they know as they will be more willing to share their physical-activity data. Hence, as opposed to the randomized pairing of users in the evaluation of the SV version of the BEN'FIT app, users should be given the opportunity and freedom to choose or invite whomever they want to collaborate with. Finally, the PHA should be equipped with a chat app to enable collaborative partners communicate with one another.

Guideline #4: Allow users to compare their performance with others' [Social Comparison]

Users should be given the opportunity to compare their performance of physical activity with one another. Implicitly, this can be achieved by allowing users to cooperate and monitor one another's performance and achievements. This social strategy is more likely to be effective in the collectivist culture than in the individualist culture. In S2c, while the percentage of favorable comments made about Social Comparison by the collectivist participants (15%) is not largely different from that made by the individualist participants (18%), the percentages of favorable comments made by both groups are. 44% of the individualist participants made unfavorable comments about Social Comparison compared with 10% of the collectivist participants. In the collectivist culture, Social Comparison is more likely to be effective because it puts social pressure on and pushes users to act when they see their partners making progress in their performance and achievements. On the other hand, Social Comparison is less likely to be effective in the individualist culture because users are concerned about privacy and confidentiality and are indifferent to the physical activity (performance and achievements) of others. To overcome the challenge of privacy and confidentiality, users, regardless of culture, should be allowed to use the PHA anonymously and to choose or invite whomever they want to collaborate with. In this regard, with respect to Social Comparison, P142 (an individualist participant) commented, "*I think this would be very convincing, especially if I was compared to my family members, but I would have to be able to add my contacts myself (ie not linked account to social media), because it wouldn't motivate me if I was given comparisons to some random person I haven't seen in years.*"

Guideline #5: Allow users to compete with one another [Competition]

Users should be given the opportunity to compete with others to motivate them to exercise more and achieve their goals. This could be realized by using a leaderboard, in which the high and low performers are at the top and bottom of the board, respectively. For example, in S3d, P54 requested "*[a] chart that compares how well [I] did compared to others.*" However, this feature, which fosters comparison, has to be implemented with caution as it can demotivate users that are lagging behind or not measuring up to the high performers. As such, Competition should be based on users with similar goals, skill sets, gender, etc., to avoid undue advantage fostered by natural abilities over others. For example, research [201][280][281] shows that men are physically stronger than women and thus are more likely to engage in physical activity. As a result, having women and men compete against one another to reach the same goal may be unfair. For example, P220 commented, "*...won't want to engage in a competition as our strengths, goals and targets are not same.*" Similarly, P47 commented, "*This seems motivating to me, but it might be difficult to win against people who are more fit or who have more time to exercise, which would have to be controlled for.*" Particularly, P32 commented, "*People burn different calories based on bw [bodyweight]. This is apples and oranges.*" One work around is using users' percentage improvement as a basis of positioning on the leaderboard. In that case, the app would not be comparing "*apples and oranges*" as P32 remarked.

Guideline #6: Allow users to view partners' performance and achievements [Social Learning]

Users should be given the opportunity to learn about the performance and achievements of their collaborative partners. This can be realized by user notification when the user's partners achieve their goal or reach a milestone. This social strategy is more likely to be effective in the collectivist culture than in the individualist culture. Overall, in S2c, the collectivist group made favorable comments about Social Learning (+14%), while the individualist group made unfavorable comments (-13%). One main reason why Social Learning is more likely to be effective in the collectivist culture is that collectivist users are more likely to be encouraged, challenged and motivated by the performance of others. Moreover, they are more willing to share their health data with others. In contrast, individualist users tend to not like working with others given their indifference to the physical activity of others and their unwillingness to share their data with others. In S2c, regarding Social Learning, 11% of the individualist participants (compared with 3% of the collectivist participants) commented that they were indifferent to others' exercise, goals and achievements. For example, P29 commented, "*I don't care how people I know are exercising.*" Similarly, P32 commented, "*I'm not a fan of seeing what others do. I need to focus on my own achievements.*" Moreover, 4% of the individualist participants (compared with 0% of the collectivist participants) commented that they did not like sharing their goals and progress with others. For example, P107 (an individualist participant) commented, "*I don't like sharing my progress with others.*" Similarly, P137 (an individualist participant) commented, "*I don't like share this kind of information with other.*" To overcome some of these challenges, such as individualist users' unwillingness to share their data with others, they should be given the opportunity to use the PHA anonymously and to choose or invite whomever they want to collaborate with.

Guideline #7: Allow users to set reminders and receive notifications about their and partners' physical activity [Reminder/Notification]

Users should be given the opportunity to set exercise reminders. One way to implement this is to allow users to set reminders on a weekly basis by specifying their workout days and time in line with their goals. For example, P197 requested "*[a] persuading reminder on time to exercise daily.*" In addition, users should be sent push notifications about important health information and/or partners' physical activity. These include notifications on exercise tips, motivational quotes, partner's performance/achievements, etc. For example, P121 requested a "*[c]onsistent reminder from the app to work out and motivational quotes or pics to follow with reminder.*" The Reminder/Notification strategy is more likely to be helpful to the collectivist culture than to the individualist culture, as the former group requires more external support. Evidently, in S3d, a higher percentage of the collectivist participants (28%) requested the Reminder/Notification feature than the percentage of the individualist participants (4%).

Guideline #8: Suggest/recommend useful exercises to users [Suggestion/Recommendation]

Users should be given the opportunity to receive suggestions and recommendations about useful and beneficial exercises they can perform based on their history and psychosocial characteristics. For example, P225 requested that s/he be recommended "*[t]he exercise[s] that fit my body shape.*" Similarly, P208 requested that s/he be provided a "*[s]ample that will show me the type of exercise that is fit for a pregnant woman* *or nursing mother.*" The Suggestion/Recommendation strategy is more likely to be useful to the collectivist culture than to the individualist culture given the former group's requirement of external support. In S3d, a higher percentage of the collectivist participants (7%) requested this feature than the percentage of the individualist participants (2%).

Guideline #9: Provide users with simulations of the target behaviors [Behavior Modeling]

Users should be given the opportunity to watch simulated behavior models, e.g., in the form of a video, showing them how to correctly perform commonly performed exercises such as push-ups, squats, crunches, planks, etc. This has the potential of making them achieve the maximum benefits from the types of exercise to choose to engage in. In addition, it prevents them from getting injured as a result of engaging in a given exercise the wrong way. For example, in S3d, P242 requested that s/he be provided "*[e]xercise videos that benefit a particular part of the body and duration of such exercise in a day to achieve its purpose.*" Similarly, P111 requested that s/he be provided "*[v]ideos that you can follow along and exercise to with increasing difficulty such as strength yoga or treadmill workouts.*" Approximately, there were equal percentages of participants in both collectivist (8.96%) and individualist (8.47%) cultures that requested this feature.

Guideline #10: Provide users with exercise tips and/or motivational quotes to encourage their physical activity [Exercise Tips/Motivational Quotes]

Users should be provided with exercise tips and/or motivational quotes to motivate them to engage in physical activity. Regarding Exercise Tips, in S3d, P210 requested exercise "*[t]ips on healthy living.*" Similarly, P152 requested "*[v]ery detailed instructions about the exercises and how to do them.*" Moreover, Motivational Quotes can be regarded as Verbal Persuasion, which Bandura [96] identified as one of the four sources of Self-Efficacy. Regarding this persuasive feature, P222 requested "*[w]ords of encouragement for progress made.*" Similarly, P154 requested some "*[m]otivational phrases*" to encourage his/her exercise. Approximately, there were equal percentages of participants in both collectivist (5.98%) and individualist (5.29%) cultures that requested both features in a PHA aimed at encouraging physical activity.

Guideline #11: Provide users with workout plans and routines [Workout Plan/Routines]

Users should be provided with customized work plans and/or routines to facilitate their engagement in physical activity. For example, in S3d, P145 requested that the workout plan "*would contain workout routines or goals that are able to be met with no or very little equipment and at home.*" Similarly, P194 requested a "*[c]ustomization of exercise routine with detailed explanation of each routine and its benefits.*" As P194 requested, the workout plans should be tailored to the target user based on age, gender, weight, skill level (e.g., beginner, advanced, etc.,), goals (e.g., losing weight or building muscles), lifestyle, schedules, etc. Some of this information, such as user's ultimate goal, can be requested from the user by the app through manual data input. In particular, given the user's history, the app can provide him/her with a tailored workout plan that comprises but not limited to the following: (1) the types of exercise the user should do; (2) the number of sets and reps the user should do per exercise; (4) the length of time the user should perform a given exercise at a stretch; (4) the amount of time the user should wait between set; and (5) the numbers of days in a week the user should engage in the workout. In S3d, a higher percentage of the individualist participants (4.23%) requested this feature than the percentage of the collectivist participants (2.99%).

Guideline #12: Provide users with a timer to measure the duration of their exercises [Timer]

Users should be provided with a timer that will enable them to measure how long each exercise they engage in, e.g., in a row, takes. In S3d, a higher percentage of the collectivist participants (5.96%) requested this feature than the percentage of the individualist participants (4.76%). For example, P204, in the collectivist group, requested that "*[t]he app should be able to monitor how long I exercise.*" Moreover, P123, in the individualist group, requested a timer that would measure the "*time intervals for reps and sets.*"

Guideline #13: Allow users to manually enter data about their physical activity [Data Input]

Users should be given the opportunity to manually enter and edit data about their physical activity. For example, in S3d, P237 commented that "*I would expect it [the app] to allow me to change my goals as my needs change.*" Apart from goal-setting, users should be given the opportunity to: (1) edit the time spent in doing a given exercise: this may be necessary because sometimes the timer could be on without the user actually exercising, e.g., mistakenly or while the user is testing how the timer works; and (2) enter their calories intake, which will enable the app to calculate their overall calories burned for a given period. For example, P52 requested "*[a] way to count calories by entering what [I] ate for the day.*"

Guideline #14: Tailor and allow users to customize the PHA [Tailoring/Customization]

The PHA (e.g., behavior models, workout plans, etc.) should be tailored to the characteristics of the users. For example, in S3d, P254 commented that s/he "*[w]ouldn't want it to be a one size fits all app.. It can be tailored to the initial Bmi of the user.*" Moreover, users should be given the opportunity to customize the application as well. In particular, P194 requested the "*[c]ustomization of exercise routine with detailed explanation of each routine and its benefits.*" In S3d, a higher percentage of the collectivist participants (4.48%) requested this feature than the percentage of the individualist participants (0.53%).

Guideline #15: Provide the users with a list of exercises to choose from [List of Exercises]

Users should be provided with a list of exercises targeting different body parts that they can choose from. In addition, instructions and/or videos of behavior models demonstrating how these exercises can be correctly performed should be provided to the users. In particular, P42 commented that "*I would expect it to list a variety of different exercises to choose from and have a little information about how to perform the exercise and how many calories each exercise burns.*" Moreover, P44 requested "*[t]argeted exercises for different body* *parts.*" In addition, a particular type of exercise can have different variations targeted at users with different goals and skill sets (e.g., beginner, advanced, expert, etc.).

Guideline #16: Provide users with an exercise scheduler and planner [Exercise Scheduler/Planner]

Users should be provided with an exercise scheduler that enables them to plan their exercise over a given period (e.g., weekly). The exercise scheduler can be likened to goal-setting. However, the user is not just specifying calories to be burned for a given period, but the type, days and time of exercise as well as setting reminders. The exercise schedules can be synced to the users' electronic calendar, e.g., Google Calendar. This particular feature is more important to the individualist users. In S3d, 3% of the individualist participants, compared with 0% of the collectivist participants, requested the Exercise Scheduler/Planner feature. For example, P25 remarked that "*[t]he most important key feature would have to be being able to schedule my routine and having reminders as well.*" Moreover, P142 requested the "*[a]bility to plan what days you want to exercise ie every second day then being notified on those days.*"

Guideline #17: Allow users to view the history and summary statistics of their physical activity [Summary Statistics/Exercise History]

Give users the opportunity to view the history and summary statistics of their activities over a given period. Both features were specifically requested by the individualist participants (4%). Regarding Exercise History, in S3d, P50 commented that "*I would expect it to have a screen that has more detailed information like a listing of days I exercised and how much time I spent on which exercise.*" Similarly, P137 requested "*[h]istorical data to see how much exerc[ise] I do each day.*" Moreover, regarding Summary Statistics, P23 requested "*monthly goal statistics,*" while P156 requested "*the ability to track statistics and progress.*"

9.5 Conclusion

In this chapter, I presented the results of the evaluation of an actual PHA (BEN'FIT) in a four-week pilot study in the field. The study was aimed at investigating the overall and culture-tailoring effectiveness of the PHA. The findings of the investigation are summarized as follows: (1) the persuasive versions of the app (PV and SV) are more effective than the control version (CV); (2) the PV version is more effective than the SV version in the individualist culture; (3) the SV version is more effective than the PV version in the collectivist culture; (4) the PV version is more effective in the individualist culture than in the collectivist culture; (5) the SV version is more effective in the collectivist culture than in the individualist culture; (6) collectivist users are more likely to engage in walking than individualist users; (7) regardless of culture, users are more likely to engage in walking than in bodyweight exercise. Moreover, I validated and refined prior PT design guidelines based on new evidence from the application domain. The main contributions and limitations of the study and future work are discussed in Chapter 10.

10 Conclusion

This chapter focuses on the seventh and final step of the EMVE-DeCK Framework (Figure 10.1). Specifically, it presents: (1) the summary of the user studies, the theory-based EMVE-DecK Framework, and the design and evaluation of the culture-tailored persuasive health application (PHA); (2) the summary and synthesis of the main findings; (3) the main contributions of the dissertation to knowledge; (4) the limitations of the dissertation; and (5) future work.

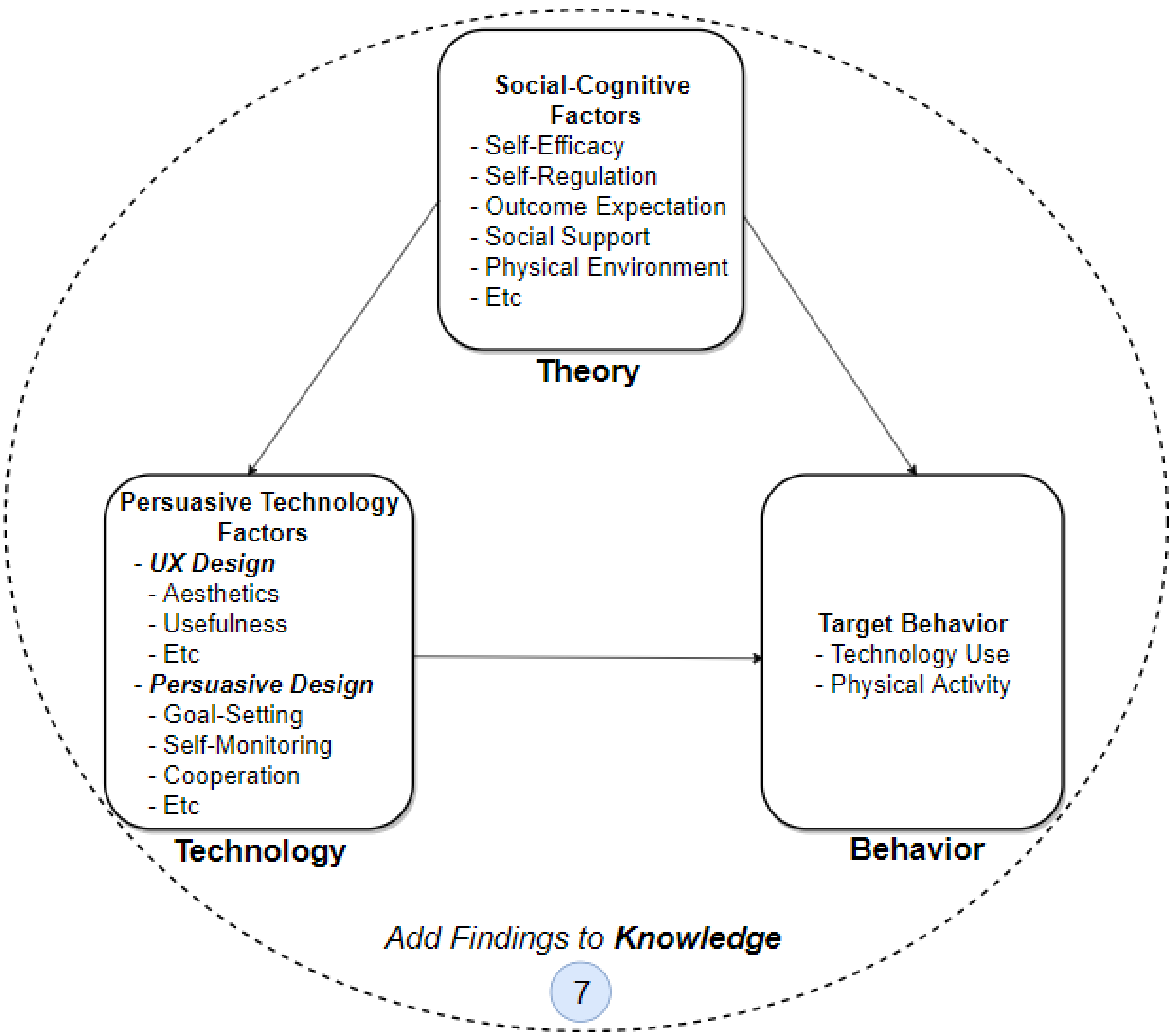

Figure 10.1: Situating the dissertation's contributions to knowledge in the EMVE-DeCK Framework

10.1 Summary of Research

In this dissertation, using the Design Science Research Methodology (DSRM) [67], Hofstede's [41] cultural framework (individualism vs. collectivism), Social Cognitive Theory (SCT) [86] and Technology Adoption Model [60][58], I conducted and presented a number of user studies that informed the development of a culture-tailored PHA. The studies, which examined the moderating effect of culture, include: (1) Investigation of the target audience's theoretical determinants of physical activity; (2) Investigation of the target audience's persuasion profile in the application domain; (3) Investigation of the target audience's Persuasive Technology Adoption (Acceptance and Use) Models based on a PHA prototype; (4) Design and implementation of a culture-tailored PHA based on empirical evidence; (5) Pre-Evaluation of the user experience (UX) design of the actual PHA; (5) Investigation of the Persuasive Technology Acceptance Model (PTAM) for an actual PHA; and (6) Evaluation of the overall and culture-tailoring effectiveness of the actual PHA in the field.

10.1.1 Theory-Based PT Design Framework

Using a systematic approach based on the DSRM and Bandura's Reciprocal Determinism Triad [79], I lay out a theory-grounded framework called "EMVE-DeCK," which researchers/designers can draw on in the development of a PT intervention for a target group. The framework is a process model, which comprises seven steps: (1) Explain: Employ "Theory" to *explain* the target "Behavior" by uncovering the relationship between the "Behavioral Determinants" and the target "Behavior"; (2) Map: *Map* the significant "Behavioral Determinants" in the "Theory" domain to "Persuasive Strategies" in the "Technology" domain; (3) Validate: *Validate* the target users' receptiveness to the "Persuasive Strategies" in the "Technology" domain; (4) Explain: Employ "Theory" to *explain* the adoption of the proposed persuasive "Technology" by uncovering the relationship between the UX/persuasive "Design Determinants" and the proposed "Technology Adoption"; (5) Design: *Design* and implement theory-driven, tailored persuasive "Technology"; (6) Change: Deploy "Technology" to *change* "Behavior" in the field; and (7) Knowledge: Contribute "Findings" to *Knowledge*.

In a nutshell, the EMVE-DeCK design process model entails ***the application of "Theory" and "Technology" to explain and change "Behavior," respectively***. This process model can be adopted in other domains than physical activity, e.g., healthy eating, smoking cessation, etc. However, researchers and intervention developers need not follow all of the steps in the design process due to limited or lack of resources, e.g., time, money, etc. For example, to develop a PT intervention for a target population, researchers/developers could embark on the first two steps only and use the findings to inform the design and implementation of the intervention. Alternatively, researchers/developers could gather information on the target population's theoretical determinants of behavior from the existing literature (if available) and progress to the third step in the application domain. This step entails uncovering the persuasion profiles of the target audience to narrow down the set of persuasive strategies that will be implemented in the PT intervention.

10.1.2 Design and Evaluation of the Culture-Tailored PHA

In the theory domain (S1), using the SCT, I found that personal factors (Self-Efficacy and Self-Regulation) and social factors (Social Support) are the strongest determinants of physical activity in the individualist and collectivist cultures, respectively. These culture-specific determinants were mapped to persuasive strategies and validated in the application domain (S2). Moreover, in S3, I found that *perceived aesthetics* and *perceived usefulness* are the most important UX design attributes that drive the acceptance of a PHA. To motivate regular physical activity in two different types of culture, I designed and implemented a theory-informed, culture-tailored mobile PHA called BEN'FIT. The PHA comprises a personal version (PV) and a social version (SV), which are tailored to the individualist and collectivist cultures, respectively. The PV version is equipped with Goal-Setting/Self-Monitoring, Reward and Behavior Model. Moreover, the SV version is equipped with group-based Goal-Setting/Self-Monitoring, group-based Reward, Cooperation, Social Learning, Social Comparison and Behavior Model. Specifically, the Behavior Model in both versions is gender-/race-tailored to the users. To evaluate the intervention, I developed a control version (CV) called EXLOGGER, which is basically an electronic journal app for logging exercises and step counts. The CV version was specifically developed to compare the adoption rate and effectiveness of PV and SV against it.

To evaluate the overall effectiveness and culture-tailoring of the PHA, I conducted a field study using Nigeria (collectivist culture) and Canada/United States (individualist culture) as a case study. The evaluation of the PHA is based on a number of metrics: churn rate, feedback rate to the researcher/developer, average physical activity level per week, average physical activity status per week and peer-to-peer engagement via the chat app in the SV version). The evaluation showed that: (1) the PV version was more effective than the CV version; (2) the SV version was more effective than the CV version; (3) the PV version was more effective than the SV version for the individualist culture.; (4) the SV version was more effective than the PV version for the collectivist culture; (5) the PV version was more effective for the individualist culture than for the collectivist culture; (6) the SV version will be more effective for the collectivist culture than for the individualist culture; (7) collectivist users are more likely to engage in walking than individualist users; and (8) users, regardless of culture, are more likely to engage in walking than engage in exercise.

10.2 Summary of Main Findings

The main findings of this dissertation can be classified into two broad areas of Human-Computer-Interaction (HCI) design: *UX design* and *persuasive design.*

10.2.1 UX Design

In S4, I triangulated the PTAM based findings from S3a and S4a. I summarize the key culture-specific findings using the Elaboration Likelihood Model (ELM) as a theoretical framework [282]. The ELM postulates two main routes to persuasion: *central* and *peripheral*. The central route (a longer path) often leads to enduring persuasion (e.g., change of behavior); the peripheral route (a shorter path) barely does.

In the PTAM investigations (S3a and S4a), the culture-specific models (Figure 6.5, Figure 6.6, Figure 8.5 and Figure 8.6) showed that the collectivist group has a long path to the acceptance of a PHA, while the individualist group has a long path as well as a longer path mediated by *perceived persuasiveness*. The culture-specific paths to the PHA acceptance are illustrated in the simplified model shown in Figure 10.2.

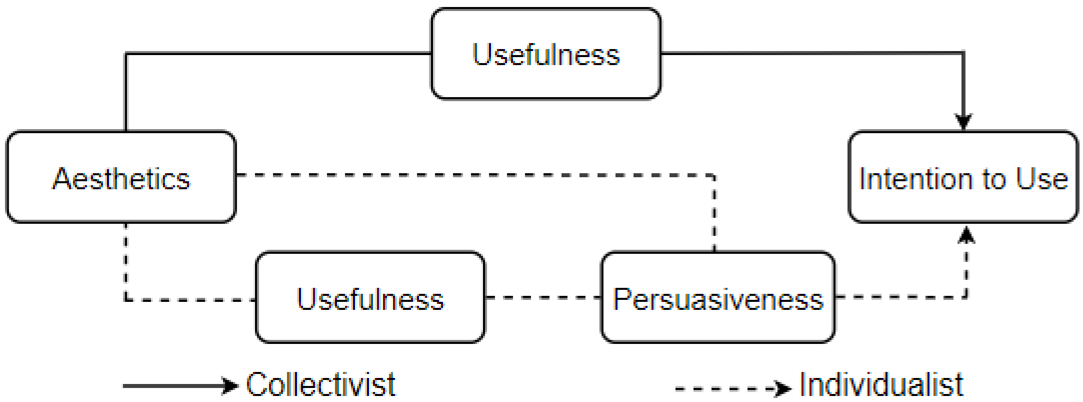

Figure 10.2: Abstract model showing the culture-specific paths to persuasive technology acceptance

For the collectivist culture, the path to acceptance is *perceived aesthetics* → *perceived usefulness* → *intention to use* (long). On the other hand, for the individualist culture, the path to acceptance is composite: (1) *perceived aesthetics* → *perceived persuasiveness* → *intention to use* (long); and (2) *perceived aesthetics* → *perceived usefulness* → *perceived persuasiveness* → *intention to use* (longer). Figure 10.2 shows that *perceived aesthetics* and *perceived usefulness* (both of which, combined, can be regarded as a system character [236]) are the most important UX design attributes of a PHA as the total-effect analysis showed in S3a and S4a.

In the context of the ELM, a path such as "aesthetics → intention" (which is non-significant in the PTAM) can be regarded as a peripheral path to the acceptance of a PHA. Moreover, paths such as "aesthetics → usefulness → intention" and "aesthetics → persuasiveness → intention" can be viewed as a short central path to the acceptance of a PHA. Finally, a path such as "aesthetics → usefulness → persuasiveness → intention" can be regarded as a long central path. The ELM holds that the central path is more likely to lead to an enduring behavior change, as it involves more careful evaluation of the persuasive system (which the ELM regards as elaboration). In the simplified model, elaboration can be viewed as the evaluation of the *perceived usefulness* of the PHA: how it would benefit the users if they accept it. According to the ELM [282], when users undergo elaboration, if the presented message (i.e., system) is well thought of and logical (i.e., strong), it will persuade the recipient. However, if the message is not well reasoned, it will fail to persuade the recipient, leading to the use of auxiliary attributes or surface/visual cues (in the case of the PTAM, *perceived aesthetics*) in decision-making. As the simplified model shows, both cultural groups undergo elaboration, which entails evaluating the *perceived usefulness* of the PHA. On one hand, the collectivist users tend to make their *intention to use* a PHA based on the *perceived usefulness*, which tends to mediate *perceived aesthetics*. On the other hand, the individualist users tend to make their *intention to use* a PHA through the mediation of *perceived aesthetics* by *perceived usefulness* and *perceived persuasiveness*.

One possible explanation for the mediation effect by *perceived persuasiveness* in the elaboration of the individualist group before acceptance is that it is more likely to be critical of HCI artifacts than the collectivist group [119]. For example, in S4b, the ANOVA results (Table 8.15) showed that the individualist group was more critical of the UX design of the CV version than the collectivist group. As such, the individualist group's path to acceptance, in the context of the ELM, is more likely to be longer, for example, by involving *perceived persuasiveness*, which is defined as the "*integration of the individual's subjective evaluation of the system and its impact on the self*" (p. 5) [109]. Based on the PTAM I presented in S3a and S4a, the subjective evaluation of the system and its impact on the user (i.e., its *perceived persuasiveness*) can be said to be determined by the affective evaluation (*perceived aesthetics*) and cognitive evaluation (*perceived usefulness*) of the PHA. This is evident in the distilled model for both cultural groups shown in Figure 10.2.

It is noteworthy that, with regard to attitude (replaced by *perceived persuasiveness* in the PTAM), some researchers (e.g., [108]) have shown that it is redundant, leading to its exclusion from the TAM to achieve parsimony. Yet, other researchers (e.g., [58]) have argued that attitude is an integral part of the TAM and presented empirical evidence to support their argument. With regard to *perceived persuasiveness* (a proxy for attitude in the PTAM), my current findings show that its importance in the PTAM may depend on the target group. The simplified model (Figure 10.2) shows that *perceived persuasiveness* is important in the individualist model but not important in the collectivist model. This indicates that the individualist group has a longer central path to persuasion than the collectivist group given the significance of *perceived persuasiveness* in the individualist model. This suggests that individualist users who find a PHA persuasive (e.g., like it) and adopt it are more likely to use it for a longer time than collectivist users who find it useful.

10.2.2 Persuasive Design

By synthesizing all of the empirical findings in the theory and application domains based on self-reports and storyboards with those from the evaluation of BEN'FIT in the field, I arrive at the abstract model shown in Figure 10.3 to explain the influence of PT on the physical-activity behavior of the target audience. I call this model, which is based on Bandura's Reciprocal Determinism Triad (see Figure 2.1), the culture-specific PT-driven paths to engagement in physical activity. It is a refinement of the physical-environment-driven path to engagement in physical activity (shown in Figure 5.8) based on new findings from the field.

Basically, the model encapsulates the conclusions I arrived at based on the evaluation of the PHA in the field (presented in Chapter 9), which replicate the findings in S2. On one hand, PT is more likely to stimulate social engagement in the collectivist culture, (which influences physical activity) than in the individualist culture. On the other hand, PT is more likely to stimulate personal engagement in the individualist culture, (which influences physical activity) than in the collectivist culture. However, personal engagement with PT

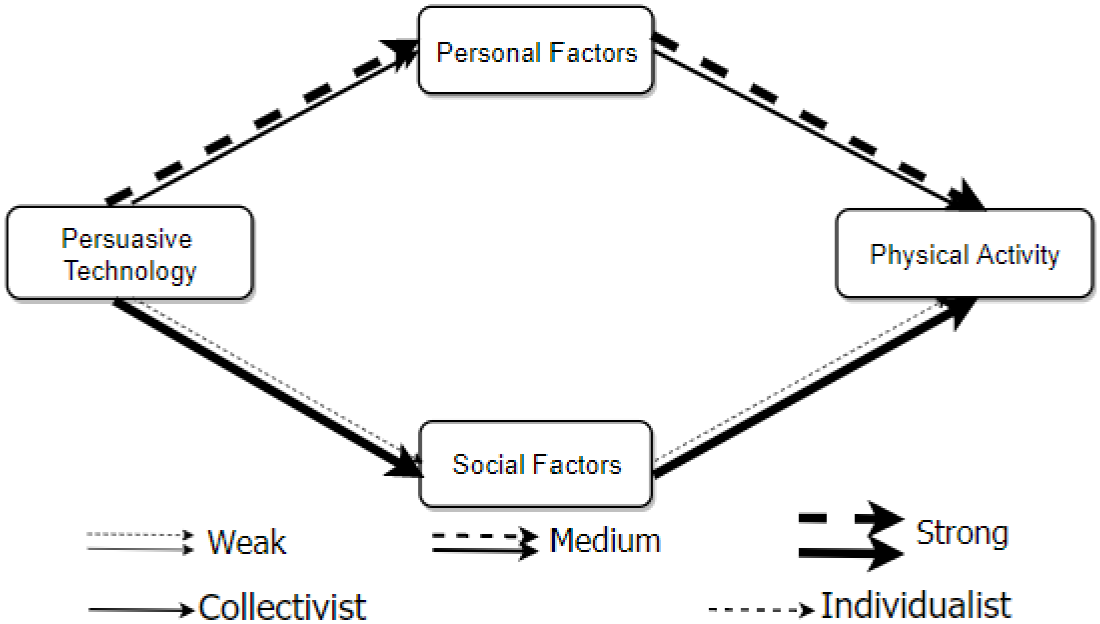

Figure 10.3: Abstract model showing the strength of the culture-specific paths to physical activity

is more likely to drive physical activity in the collectivist culture (medium) than social engagement with PT is likely to drive physical activity in the individualist culture (weak). The reasons for the latter include the higher level of sensitivity of individualist users to privacy and confidentiality, being indifferent to others' physical activity, having the view that physical activity is a personal journey and not a social one, dislike for social comparison, etc. That said, overall, personal strategies should be used to motivate behavior change in the individualist culture, while social strategies should be used in the collectivist culture.

10.3 Contributions

A number of contributions are made to the existing HCI and PT literature on designing theory-driven PHAs (to motivate behavior change) using a systematic approach. I briefly discuss these contributions to knowledge.

10.3.1 Theory- and Model-Driven Approach

My first contribution to knowledge is that I demonstrated how researchers and designers of PHAs can employ theory to inform the development of PT interventions to motivate behavior change. Using the SCT as a theoretical behavioral framework and Hofstede's cultural framework as a basis for population segmentation, I showed in the social-cognitive model that the strongest determinants of Physical Activity for the individualist culture are Self-Efficacy and Self-Regulation and that for the collectivist culture is Social Support. All of these culture-specific determinants are mapped to corresponding persuasive strategies in the application domain. This dissertation is the first to show how the SCT, in concert with Hofstede's cultural framework, can be used to inform the design and development of culture-tailored PHAs in the physical-activity domain.

10.3.2 PTAM: UX Design Attributes that Explain Acceptance of a PHA

I showed that, regardless of culture, *perceived usefulness* and *perceived aesthetics* are the strongest determinants of the *intention to use* a PHA (S3a). These findings were confirmed in a follow-up investigation (S4a). They demonstrate that, in the design of a PHA, users do not only care about *utility* (*perceived usefulness*) but *beauty* (*perceived aesthetics*) as well. While utility, which is a pragmatic attribute, engages users' cognition, beauty, which is a hedonic attribute, appeals to their emotion [248]. This finding suggests that, although a PHA such as a fitness app is a utilitarian system tha provides instrumental values, designers should strike a balance between both *usefulness* and *aesthetics* in their UX design to realize a greater adoption rate and foster prolonged use [248]. Moreover, I showed in the PTAM that while *perceived persuasiveness* is likely to mediate the effect of *perceived usefulness* on *intention to use* for the individualist culture, this is not the case for the collectivist culture. Finally, I showed that the effect of *perceived usefulness* and *perceived persuasiveness* on *intention to use* is stronger in the collectivist and individualist cultures, respectively.

10.3.3 PTUM: Persuasive Design Features that Explain the Use of a PHA

Aside from showing that users, regardless of culture, are receptive to Goal-Setting/Self-Monitoring (S2a), I showed that the feature can predict the use of a PHA as well (S3c). Based on a multichoice motivational model, which I called Persuasive Technology Use Model (PTUM), I showed that, regardless of culture, Goal-Setting/Self-Monitoring is the most persuasive (design) feature that explains the *intention to use* a PHA. This finding underscores the importance of Goal-Setting/Self-Monitoring, which I regard as an essential persuasive feature every minimally viable PHA aimed to motivate behavior change should have. Moreover, I drew parallels between the *perceived usefulness* of a PHA and its persuasive features, which motivate and facilitate behavior change. I argued that the *perceived usefulness* of a PHA, which is a utilitarian construct in the UX design domain, can be mapped to its persuasive features in the persuasive design domain. In this regard, I showed empirically that, in the UX and persuasive design domains, *perceived usefulness* and Goal-Setting/Self-Monitoring, respectively, are significant determinants of the *intention to use* a PHA.

10.3.4 Validation of Empirical Findings based on Users' Perception in the Field

This dissertation is the first, in the context of PT and the effect of culture, to demonstrate that subjective empirical findings based on self-reports can be replicated in an experimental setting through objective measurement of users' physical activity. Specifically, using a mixed-method approach, I showed, through the use of storyboards and an actual PHA evaluated in the field, individualist users are more likely to be receptive to personal strategies (such as Goal-Setting and Self-Monitoring). This resulted in the tailoring of the PV version of the BEN'FIT app to members of the individualist culture. On the other hand, I showed that collectivist users are more likely to be receptive to social strategies (such as Cooperation and Social Learning). This resulted in the tailoring of the SV version of the BEN'FIT app to members of the collectivist culture.

10.3.5 Provision of Validated PT Design Guidelines in the Field

Based on several mixed-method studies cutting across self-reports and field settings and triangulation of quantitative and qualitative findings, the dissertation provides an in-the-field validated PT design guidelines for developing tailored PHA for the two types of culture. The culture-tailored PT design guidelines are based on the collectivist and individualist social-cognitive models of physical activity and persuasion profiles. Rather than employ a one-size-fits-all PHA, which is ineffective [26], designers in the health domain can leverage the presented evidence-based guidelines to tailor their PT interventions to different target populations categorized as collectivist and individualist. In the physical-activity domain, this dissertation is one of the first to provide in-the-field-validated culture-specific design guidelines using a systematic approach that: (1) cut across the theory and application domains; and (2) employed a triangulation of quantitative and qualitative findings.

10.4 Limitations

The studies presented in this dissertation have a numbers of limitations, most of which are presented at the end of each chapter. That said, I provide here a summary of the key limitations.

10.4.1 Self-Reports and Mode of Administration

Excluding the fifth study (S5) presented in Chapter 9, most of the user studies in the dissertation are based on self-reports and user perceptions, which are susceptible to respondent bias (e.g., memory bias, recall bias, misinterpretation, etc.). A typical limitation of self-reports is the mode of administration of questionnaires (including the medium of delivery and the method of contacting respondents). The method of contact, the mode of presentation of the questionnaires and recruitment platforms were different for the two cultural groups in most of the studies. These differences can affect the data quality [283]. For example, in the first study (S1), the medium of presentation of questionnaire is online for the individualist group, but paper-based for the collectivist group. Particularly, the paper-based questionnaire presented to the Nigerian group in S1 was subject to data-entry error during digitization, e.g., mistyping of the Likert-scale data into Microsoft Excel sheets. This could affect the accuracy of the presented results in one way or the other.

10.4.2 Testing for Measurement Invariance across Cultural Groups

The items that measure a given construct might mean different things to or be interpreted differently by different groups. Thus, to compare different groups' construct mean ratings, it is recommended that a measurement invariance test be conducted. The measurement invariance test indicates whether the same construct is being measured across multiple groups [284]. However, in the between-group analyses for the respective constructs in S1b, S2a and S4b, I did not conduct the said test required for multigroup mean comparisons. The lack of this test is one of the limitations of the dissertation's statistical analyses.

10.4.3 Definition of Culture Based on Country of Origin

This dissertation adopted Hofstede's [41] individualism vs. collectivism dimension, with culture equated with country, in the study of the influence of culture in PT interventions in the physical-activity domain. However, some of Hofstede's critics have argued that culture cannot be simply defined on the basis of national boundaries [118]. For this reason, regarding the individualism vs. collectivism dimension, we cannot classify everyone in the respective target populations as completely either collectivist or individualist. This means not every Canadian or American is individualist; some may be collectivist. Similarly, not every Nigerian is collectivist; some may be individualist. This assertion is evident in the culture-specific preferences with regard to the two versions of the PHA. Specifically, in the recruitment data used to preselect qualified participants (see Figure 8.2), I found that 50% of Nigerians preferred to use the fitness app either alone (i.e., the PV version) or with a partner (i.e., the SV version). This indicates that 50% of the recruited Nigerian participants had a collectivist or an individualist mindset. Moreover, I found that 77% of Canadian/American preferred to use the fitness app alone (i.e., the PV version), while 23% preferred to use it with a partner (i.e., the SV version). This indicates that 77% and 33% of the recruited Canadian/American participants had individualist and collectivist mindsets, respectively. In the light of these findings, the conclusion that the PV version is more likely to be effective in the individualist culture than the SV version may not be applicable to every Canadian and American. On the other hand, the conclusion that the SV version is more likely to effective in the collectivist culture than the PV version may not be applicable to every Nigerian. In this regard, personalizing PTs at the individual level is required.

10.4.4 Generalization of Culture-Specific Findings to Other Countries

In the user studies, Nigeria and Canada/United States are used as case studies of collectivist and individualist cultures, respectively. However, in the Hofstede's framework, other countries in other continents are classified as collectivist and individualist cultures as well. For example, China in Asia is classified as a collectivist culture. Moreover, United Kingdom in Europe is classified as an individualist culture [41][124][140]. That said, given that the composition of the two cultural groups is limited to Nigeria and Canada/United States, the culture-specific findings may not generalize to the other countries classified as collectivist and individualist. Hence, futher work needs to done in this area to investigate the generalizability of the current findings.

10.4.5 Composition of Cultural Group and Limited Sample Size

In this dissertation, I categorized Canadians and Americans as the individualist group on the basis of Hofstede's individualism dimensional index, which is 80 for Canada and 91 for the United States, respectively [41][124][140]. In the light of this, I assumed that Canadians and Americans do not significantly differ in their motivational mechanism without verifying it empirically. Moreover, in some of the studies, the sample size for the two subgroups are not equal or nearly equal. For example, in S5, the sample sizes for the Canadian and American subgroups greatly differ: 87.5% of the individualist group were Canadians and 12.5% were Americans. The underrepresentation of the Americans limits the in-the-field findings related to the individualist group in terms of generalizing to the American population. More broadly, for both cultural groups, the sample size used for the evaluation of the effectiveness of the PHA in the field setting is limited: collectivist group (n = 34) and individualist group (n = 25). Specifically, the CV version of the health application comprises 6 and 4 valid participants only in the collectivist and individualist groups, respectively. The limited sample size, especially regarding the participants that used each version of the PHA in each culture, may affect the generalizability of the findings to the entire Nigerian and Canadian/American populations.

10.4.6 Combination of Persuasive Features

In this dissertation, each of the two intervention versions of the PHA (PV and SV) employs a combination of persuasive features to motivate behavior change in both cultures. For example, the PV version employs Goal-Setting/Self-Monitoring and Reward, while the SV version employs group-based Goal-Setting/Self-Monitoring, group-based Reward, Cooperation, Social Learning and Social Comparison. In addition, each of the versions contains other persuasive features such as Behavior Model, Reminder, etc. This makes it difficult to pin-point which of the persuasive features (individually or in combination) can be associated with the physical activity of the target audience.

10.5 Future Work

This dissertation has presented significant findings on the influence of culture in the social-cognitive determinants of physical-activity behavior, users' receptiveness to persuasive strategies (features) in the application domain, and the adoption (acceptance and use) of a PHA. Moreover, it validated the culture-specific findings on the theoretical determinants of physical activity in the application domain—both at the level of perception (using exercise-based storyboards) and in the field (using an actual fitness app). That said, there are a number of relevant investigations which were not part of this dissertation. In future work, I look forward to addressing them. Moreover, other researchers could take on them as well.

10.5.1 Effect of Other Demographic Variables than Culture

Although this dissertation as well as others in the past [125][188] has shown that culture can have a significant impact on the effectiveness of PTs, research has shown other demographic variables can influence the effectiveness of PTs as well [202][204]. However, this dissertation is only able to investigate the effect of culture without considering how it interacts with other demographic variables. Hence, in the future, in the evaluation of effectiveness of the PHA as well as the receptiveness to persuasive strategies in the physical-activity domain, I hope to investigate how culture interacts with other important demographic factors (such as gender, age, body mass index (BMI), education level, income status, etc.).

10.5.2 Effect of Persuasive Technology on Social Cognitive Beliefs

In a prior study, Oyibo et al. [32] found that the *perceived persuasiveness* of fitness applications has the potential to impact users' social-cognitive beliefs. However, this finding was based on a fitness application prototype and not an actual application. Although, in the current dissertation, the evaluation of the effectiveness of a PT intervention in the physical-activity domain was based on an actual fitness application, none of the studies investigated the actual effect of its *perceived persuasiveness* and/or use on the target users' social-cognitive beliefs. To address this limitation, I look forward to investigating how users' social-cognitive beliefs (Perceived Self-Efficacy, Perceived Self-Regulation and Outcome Expectation) before and after the PT intervention changed.

10.5.3 Effect of Social Cognitive Beliefs on Actual PT Use and Physical Activity

In the context of the Reciprocal Determinism Triad [79], which I called the Theory-Technology-Behavior model in the PT context, I investigated the relationship between the target users' social-cognitive beliefs and physical-activity behavior in S1a. However, I did not investigate the relationship between the target users' social-cognitive beliefs, on one hand, and *intention to use/actual use* a PHA and *physical activity level*, on the other hand. Hence, in future work, I hope to investigate these relationships between "Theory" and "Behavior" in a field setting.

10.5.4 Effect of UX Design Attributes on Actual PT Use and Physical Activity

Regarding the relationship between "Technology" and "Behavior" in the EMVE-DeCK Framework, I only investigated how perceived UX design attributes explain the *intention to use* a PHA (prototype and actual) in S3a and S4a, respectively. I did not investigate the possible relationship between perceived UX design attributes and the target users' *actual use* of a PHA and/or *physical activity level*. Hence, in future work, I hope to investigate these relationships in a field setting.

10.5.5 Field Validation of the Culture-Specific Effectiveness of Competition

In the mixed-method investigations on users' receptiveness to persuasive strategies (S2a and S2c), Competition turned out to be the only social strategy (among the four social strategies I investigated) that both the collectivist and individualist cultures were receptive to. However, I could not investigate its effectiveness as a social feature of a PHA in motivating behavior change in the field and the influence of culture. Hence, in future work, it would be interesting to examine in the field how effective Competition is in driving physical-activity behavior change in both types of culture and, in which culture, it is more effective. Moreover, within each culture, the Competition strategy could be compared with the Cooperation strategy as well to uncover the more effective in motivating physical-activity behavior.

10.5.6 Interrelationship among Persuasive Features in the PTUM

In the PTUM, I showed that persuasive features, such as Goal-Setting/Self-Monitoring, Reward and Competition, can directly predict the *intention to use* a PHA. However, this is not the case for the other persuasive features in the multichoice model. Although persuasive features such as Cooperation, Social Comparison and Social Learning, regardless of culture, do not have a direct relationship with the *intention to use* a PHA, they may have an indirect relationship. Thus, in future work, I look forward to testing this hypothesis by investigating the interrelationships among the persuasive features in the PTUM. It will be interesting to know whether Cooperation, Social Comparison and Social Learning, to which the collectivist culture is receptive, for example, can indirectly predict the use of a PHA in a non-multichoice model, in which the interrelationships among the persuasive features are investigated.

10.5.7 Machine Learning Algorithms for Exercise Recognition and Measure

In the PT intervention, while the participants' step counts were measured objectively using cloud-based services provided by Google Fit, their calories burned as a result of engaging in bodyweight exercises were not. Instead, a timer was employed in measuring the participants' calories burned after they had manually selected the exercise type (e.g., push-up, squat, etc.) they wanted to perform from a list. This approach to physical-activity measure is unreliable and susceptible to error, e.g., users forgetting to turn off the timer when they finish performing a given bodyweight exercise. In future work, to ensure that physical activity is objectively measured in the research on the influence of culture on the effectiveness of PT, there is a need for the use of wearables and machine learning algorithms to recognize bodyweight exercises and predict energy expended . For example, machine learning classifiers can be trained on accelerometer features from different body parts (e.g., wrist, hip, etc.) to recognize exercise types and measure calories burned [285].

10.5.8 Long-Term Effect of Persuasive Technology

In the extant literature, most of the evaluation studies on the effectiveness of PT interventions have only been carried out for a short period or on a one-time basis without a follow-up [22][286]. In certain cases, the effectiveness of PT interventions is evaluated using games, some of which are one-time [125][30]. One of the reasons for this practice is that researchers have limited resources, with doctoral students, for example, having limited time and funding to complete their research. Hence, there is a limited body of knowledge on the long-term effectiveness of PTs in changing behavior in field settings. For this reason, to increase the reliability of the findings from the evaluation of the effectiveness of fitness applications and the effect of culture, in future research, several long-term and longitudinal studies among different target populations spanning several months and even years ought to be conducted. In the context of behavior change support systems, this kind of user studies will help in evaluating the long-term effect of PT interventions on behavior change (B-Change) as well as attitude change (A-Change), which sustains behavior change [150].

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Appendix A

S1: SCT Determinants of Physical Activity

CONSENT FORM

UNIVERSITY OF SASKATCHEWAN

DEPARTMENT OF COMPUTER SCIENCE
UNIVERSITY OF SASKATCHEWAN
INFORMED CONSENT FORM

You are invited to participate in this survey aimed at identifying effective ways of designing physical activity interventions to promote healthier lifestyle in the university. Please read this form carefully, and feel free to ask the researchers any questions you might have.

Title of Study: Determinants of Physical Activity for University-Tailored Persuasive Technology Intervention

Ethics Application Number: 15-008

Researchers:
Julita Vassileva, Department of Computer Science (360-966-4886), jiv@cs.usask.ca
Kiemute Oyibo, Department of Computer Science (360-966-4886), kso544@mail.usask.ca
David Clement, African University of Science and Technology, Nigeria, cdavid@aust.edu.ng

Purpose and Procedure: The goal of this research is to identify effective ways for designing physical activity interventions to promote healthy lifestyle. Specifically, the study aims to understand the general attitude and health beliefs of students, how they vary across cultures, geographical locations and gender, and propose ways of tailoring persuasive interventions. The study may contribute to the research area of persuasive technology for healthy behavior change, user modeling, adaption and personalization. To realize this, we have designed a set of questions we need you to respond to. This can be achieved by answering the questionnaire in the next page or clicking on the survey link below or completing the paper pencil survey and submitting it to the research. It takes about 20 to 30 minutes.
http://goo.gl/forms/XIVIoFSC13

Potential Benefits: Findings from the study could lead to a better understanding and design of effective persuasive physical activity interventions aimed at promoting healthy lifestyle within the university.

Potential Risks: there are no known risks in this study.

Compensation: In appreciation for your time, you would be offered a chance (optional) to win one of 3 prizes of $50 each (for on-line participants) or rewarded with a one-hundred naira (N100) phone-credit/recharge card (for in-classroom Nigerian participants). By entering the draw, your name will not be linked to your survey responses.

Confidentiality: This survey is hosted by Google Forms, a company located in the USA and subject to US laws and whose servers are located outside of Canada. The privacy of the information you provide is subject to the laws of those other jurisdictions. By participating in this survey you acknowledge and agree that your [answers/information] will be stored and accessed outside of Canada and may or may not receive the same level of privacy protection.

Dissemination of Results: Aggregated results from this study will appear in a PhD course report, thesis and articles published in peer reviewed conferences and scientific journals.

Right to Withdraw: Participation in this survey is voluntary, and you can decide not to participate at any time, or choose not to answer any questions you don't feel comfortable with. Survey responses will remain anonymous. Since the survey is anonymous, once it is submitted it cannot be removed.

Questions: if you have any question regarding the study, please feel free to ask the researchers at any point, including at a later time. This research project has been approved on ethical grounds by the University of Saskatchewan Research Ethics Board. You could call (306) 966-2975 or email Research Ethics Office at ethics.office@usask.ca regarding any questions on your rights as a participant. Participants from Nigeria may call collect.

Follow-Up or Debriefing: If you would like to know the results of this study, you can contact the researchers.

Consent to Participate: By completing and submitting this questionnaire, your free and informed consent is implied and indicates that you understand the above conditions of participation in this study.

Figure A.1: Consent form for participants recruited online and in a classroom setting

Table A.1: Empirical scales measuring SCT constructs and the outer loading of indicators. "×" indicates items dropped from model because the outer loading on its construct is less than 0.5. "*" indicates the item in question was reversed in the building of the path models.

Construct	Low-Order Constructs and Indicators (Items)	COL	IND
Self-Efficacy (SE) – Not Confident (0) to Very Confident (10) [182]	How confident are you right now that you can exercise three times per week for 20 minutes if:		
	1) You felt stressed?	×	0.84
	2) You had to exercise alone?	0.52	0.7
	3 You did not enjoy it?	×	0.76
	4) You felt depressed?	×	0.79
	5) You felt tired?	×	0.86
	6) The weather was bothering you?	0.73	0.79
	7) You felt pain when exercising?	0.68	0.73
	8) You were too busy with other activities?	0.49	0.86
	9) You were bored by the program or activity?	×	0.78
Social Support (SS) – None (1) to Very Often (5) [181]	**Family SS (5 items)** Please rate how often anyone living in your household has said or done what is described on the left hand side during the last three months. During the past three months, my family (or members of my household):		
	1) Exercised with me.	0.71	0.78
	2) Offered to exercise with me.	0.70	0.77
	3) Gave me encouragement to stick to my exercise program.	0.82	0.77
	4) Gave me helpful reminders to exercise.	0.79	0.78
	5) Helped plan activities around my exercise schedule.	0.79	0.74
	Friends SS (5 items) Please rate how often any of your friends has said or done what is described on the left hand side during the last three months. During the past three months, my friend(s):		
	1) Exercised with me.	0.79	0.84
	2) Offered to exercise with me.	0.81	0.84
	3) Gave me encouragement to stick to my exercise program.	0.83	0.89
	4) Gave me helpful reminders to exercise.	0.8	0.78
	5) Helped plan activities around my exercise schedule.	0.78	0.84
Outcome Expectation (OE) – Strongly Disagree (1) to Strongly Agree (5) [183]	**Physical OE (5 items)**		
	1) Exercise will improve my ability to perform daily activities.	0.82	0.87
	2) Exercise will improve my overall body functioning.	0.9	0.95
	3) Exercise will strengthen my bones.	0.82	0.79
	4) Exercise will increase my muscle strength.	0.84	0.95
	5) Exercise will improve the functioning of my cardiovascular system.	0.78	0.87
	Social OE (3 items)		
	1) Exercise will improve my social standing.	0.84	0.87
	2) Exercise will make me more at ease with people.	0.86	0.91
	3) Exercise will increase my acceptance by others.	0.86	0.86
	1) Exercise will help manage stress.	0.73	0.99
	2) Exercise will improve my psychological state.	0.84	1.00
	3) Exercise will increase my mental alertness.	0.83	0.99
	4) Exercise will give me a sense of personal accomplishment.	0.73	1.00
Self-Regulation (SR) – Does Not Describe Me (1) to Describe Me Completely (5) [94]	Please indicate the extent to which each of the statements below describes you. **Exercise Goal Setting (10 items)**		
	1) I often set exercise goals.	0.62	0.84
	2) I usually have more than one major exercise goal.	0.57	0.83
	3) I usually set dates for achieving my exercise goals.	0.59	0.66
	4) My exercise goals help to increase my motivation for doing exercise.	0.68	0.83
	5) I usually keep track of my progress in meeting my goals.	0.56	0.77
	6) I have developed a series of steps for reaching my exercise goals.	0.68	0.84
	7) If I do not reach an exercise goal, I analyze what went wrong.	0.5	0.75
	8) I usually achieve the exercise goals I set for myself.	0.6	0.7

Continued on next page

Table A.1 – *Continued from previous page*

Construct	Low-Order Constructs and Indicators (Items)	COL	IND
	9) I tend to break more difficult exercise goals down into a series of smaller goals.	0.53	0.73
	10) I make my exercise goals public by telling other people about them.	×	0.52
	Exercise Planning (10 items)		
	1) I never seem to have enough time to exercise.	×	0.7
	2) *Exercise is generally not a high priority when I plan my schedule.	×	0.67
	3) *Finding time for exercise is difficult for me.	×	0.63
	4) I schedule all events in my life around my exercise routine.	0.6	0.78
	5) I schedule my exercise at specific times each week.	0.65	0.63
	6) I plan my weekly exercise schedule.	0.77	0.74
	7) *When I am very busy, I don't do much exercise.	×	0.78
	8) Everything is scheduled around my exercise routine—both classes and work.	×	0.8
	9) I try to exercise at the same time and same day each week to keep a routine going.	0.70	0.74
	10) I write my planned activity sessions in an appointment book or calendar.	0.72	0.49
Physical Environment (ENV) – Strongly Disagree (1) to Strongly Agree (4) [184]	Please tick the answer that best applies to you and your view of your neighborhood. By neighborhood we mean the area ALL around your home that you could walk to in 10-15 minutes - approx 1mile or 1.6 km. And by home we mean the residence/house from which you go to work/school.		
	1) Most of the houses in my neighborhood are detached houses.	×	0.43
	2) Many shops, stores, markets or other places to buy things I need are within easy walking distance of my home.	0.68	×
	3) There is a transit stop (such as bus stop, train, trolley or tram station) within easy walking distance of my home.	0.5	×
	4) There is an open recreation area (e.g. park, beach or other open space) within easy walking distance of my home.	0.53	0.46
	5) There are many different routes for cycling or walking from place to place in my neighborhood so I don't have to go the same way every time.	0.69	0.43
	6) Walking and cycling are unsafe because of the traffic in my neighborhood.	×	0.65
	7) Walking and cycling are unsafe because of the level of crime in my neighborhood.	×	0.58
	8) My local neighborhood is a pleasant environment for walking and cycling.	0.67	0.66
	9) I have access to exercise and sports equipment at home e.g. weights, racquets, skis for personal use.	0.54	0.58
	10) My school provides facilities to support me walking or cycling to work/school e.g. changing rooms, bike storage.	×	×
	11) I have access to exercise and sports facilities at work/school e.g. fitness center/equipment, stairs.	×	×
Physical Activity (PA) – Numerical scale containing vigorous-, moderate- and light-intensity activities [185]	**Vigorous Activities** Think about all the vigorous activities that you did in the last 7 days. Vigorous physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time. 1) During the last 7 days, on how many days did you do vigorous physical activities like heavy lifting, digging, aerobics, or fast bicycling? 2) How much time did you usually spend doing vigorous physical activities on one of those days?	0.93	0.98
	Moderate Activities Think about all the moderate activities that you did in the last 7 days. Moderate activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time. 1) During the last 7 days, on how many days did you do moderate physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking. 2) How much time (on the average) did you usually spend doing moderate physical activities on one of those days?	0.69	0.39
	Walking Think about the time you spent walking in the last 7 days. This includes at work and at home, walking to travel from place to place, and any other walking that you might do solely for recreation, sport, exercise, or leisure. 1) During the last 7 days, on how many days did you walk for at least 10 minutes at a time? 2) How much time (on the average) did you usually spend walking on one of those days?	0.69	0.39

Appendix B

S2/S3: Receptiveness to Persuasive Strategies & PT

University of Saskatchewan

CONSENT FORM

DEPARTMENT OF COMPUTER SCIENCE
UNIVERSITY OF SASKATCHEWAN
INFORMED CONSENT FORM

You are invited to participate in the survey on physical activity and persuasive technology intervention. Please read this form carefully, and feel free to ask the researchers any questions you might have.

Title of Study: Investigation of the Stages of Change and Persuasive Strategies in Home-Based Physical Activity Intervention
Ethics Application Number: BEH-17362

Researchers:
Julita Vassileva, Principal Investigator, Department of Computer Science (360-966-4886), jiv@cs.usask.ca
Kiemute Oyibo, Student Investigator, Department of Computer Science (360-966-4886), kso544@mail.usask.ca
Barnabas Ifebude, Collaborator, African University of Science and Technology, bifebude@aust.edu.ng

Purpose and Procedure:
The goal of this research is to investigate the stages of change in which individuals are, with respect to physical activity, and how they map to various persuasive strategies. This will enable a tailored intervention to individuals at different stages of change. The study may contribute to the general research area of Persuasive Technology (PT) design. To achieve this, we have designed a set of questions that we need you to respond to.

The questionnaire will take about 15-to-20 minutes to complete.

Potential Benefits: Findings from the study may provide more insight into how various influential strategies affect individuals across different demographics. This will help in tailoring PT applications to different demographics.
Potential Risks: There are no known risks to participating in this survey.

Compensation: In appreciation for your time, you would be compensated with an optional N200 recharge (phone credit) card. Your email address will be required to send you your recharge card.

Confidentiality: The research data will be available only to the researchers and will be stored minimum of five years on a password-protected computer system.

Dissemination of Results: Aggregated results from this study will appear in articles and papers published in peer reviewed conferences and scientific journals.
Right to Withdraw: Participation in this survey is voluntary, and you can decide not to participate at any time by closing the survey. Survey responses will remain anonymous. Since the survey is anonymous, once it is submitted it cannot be removed.

Questions: If you have any questions concerning the study, please feel free to ask at any point; you are also free to contact the researchers if you have questions at a later time. This research project has been approved on ethical grounds by the University of Saskatchewan Research Ethics Board. You could call (+1 306) 966-2975 or email Research Ethics Office at ethics.office@usask.ca regarding any questions on your rights as a participant. Out of town participants within Canada may call toll free (888) 966-2975. Out of country participants may call (+1 306) 966-2975.

Follow-Up or Debriefing: If you would like to know the results of this study, you can contact the researchers above. Also, participants may find out about the results of the study through the MADMUC website http://madmuc.usask.ca.

Consent to Participate:
By completing and submitting this questionnaire, your free and informed consent is implied and indicates that you understand the above conditions of participation in this study.

Figure B.1: Consent form for collectivist participants recruited via email

CONSENT FORM

DEPARTMENT OF COMPUTER SCIENCE
UNIVERSITY OF SASKATCHEWAN
INFORMED CONSENT FORM

UNIVERSITY OF SASKATCHEWAN

You are invited to participate in the survey on physical activity and persuasive technology intervention. Please read this form carefully, and feel free to ask the researchers any questions you might have.

Title of Study: Investigation of the Stages of Change and Persuasive Strategies in Home-Based Physical Activity Intervention
Ethics Application Number: BEH-17362

Researchers:
Julita Vassileva, Principal Investigator, Department of Computer Science (360-966-4886), jiv@cs.usask.ca
Kiemute Oyibo, Student Investigator, Department of Computer Science (360-966-4886), kso544@mail.usask.ca

Purpose and Procedure:
The goal of this research is to investigate the stages of change in which individuals are, with respect to physical activity, and how they map to various persuasive strategies. This will enable a tailored intervention to individuals at different stages of change. The study may contribute to the general research area of Persuasive Technology (PT) design. To achieve this, we have designed a set of questions that we need you to respond to.

This can be achieved by answering the 20-to-30 minute questionnaire by clicking on the survey link below.
https://fluidsurveys.usask.ca/s/mturk-skimres/

Potential Benefits: Findings from the study may provide more insight into how various influential strategies affect individuals across different demographics. This will help in tailoring PT applications to different demographics.
Potential Risks: There are no known risks to participating in this survey.

Compensation: In appreciation for your time, you would be compensated with $1.50.

Confidentiality: This survey is hosted by Fluid Survey, a company located in Canada and subject to Canadian laws. The privacy of the information you provide is subject to the laws of the Canadian jurisdictions. By participating in this survey you acknowledge and agree that your [answers/information] will be stored and accessed on the Fluid Survey server hosted in Canada.

Dissemination of Results: Aggregated results from this study will appear in articles and papers published in peer reviewed conferences and scientific journals.
Right to Withdraw: Participation in this survey is voluntary, and you can decide not to participate at any time by closing the survey. Survey responses will remain anonymous. Since the survey is anonymous, once it is submitted it cannot be removed.

Questions: If you have any questions concerning the study, please feel free to ask at any point; you are also free to contact the researchers if you have questions at a later time. This research project has been approved on ethical grounds by the University of Saskatchewan Research Ethics Board. You could call (306) 966-2975 or email Research Ethics Office at ethics.office@usask.ca regarding any questions on your rights as a participant. Out of town participants within Canada may call toll free (888) 966-2975. Out of country participants may call (306) 966-2975 collect.

Follow-Up or Debriefing: If you would like to know the results of this study, you can contact the researchers above. Also, participants may find out about the results of the study through the MADMUC website http://madmuc.usask.ca.

Consent to Participate:
By completing and submitting this questionnaire, your free and informed consent is implied and indicates that you understand the above conditions of participation in this study.

Figure B.2: Consent form for individualist participants recruited on Amazon Mechanical Turk

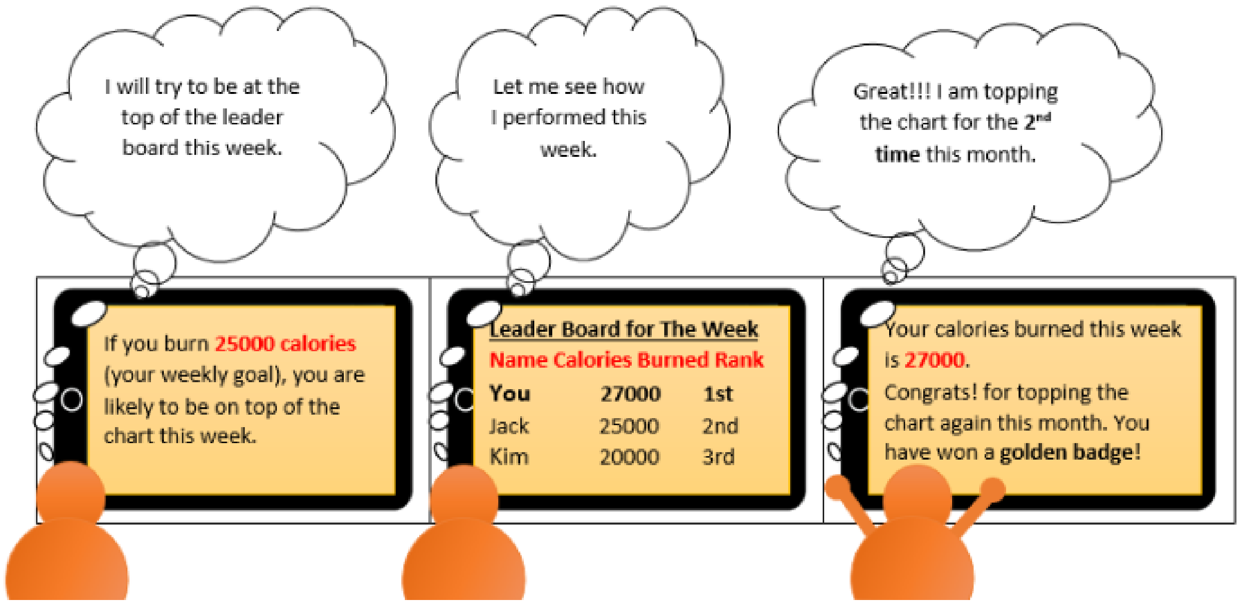

Figure B.3: Storyboard illustrating competition persuasive feature

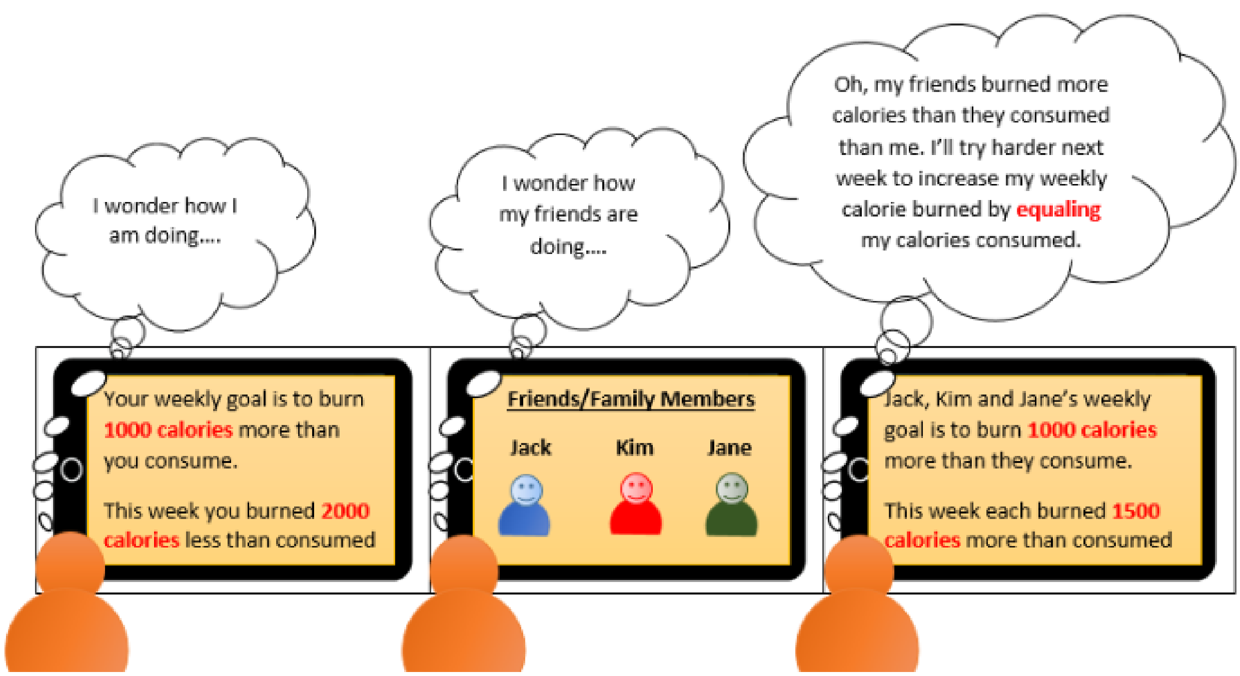

Figure B.4: Storyboard illustrating social comparison persuasive feature

Appendix C

Design of Behavior Models Implemented in BEN'FIT

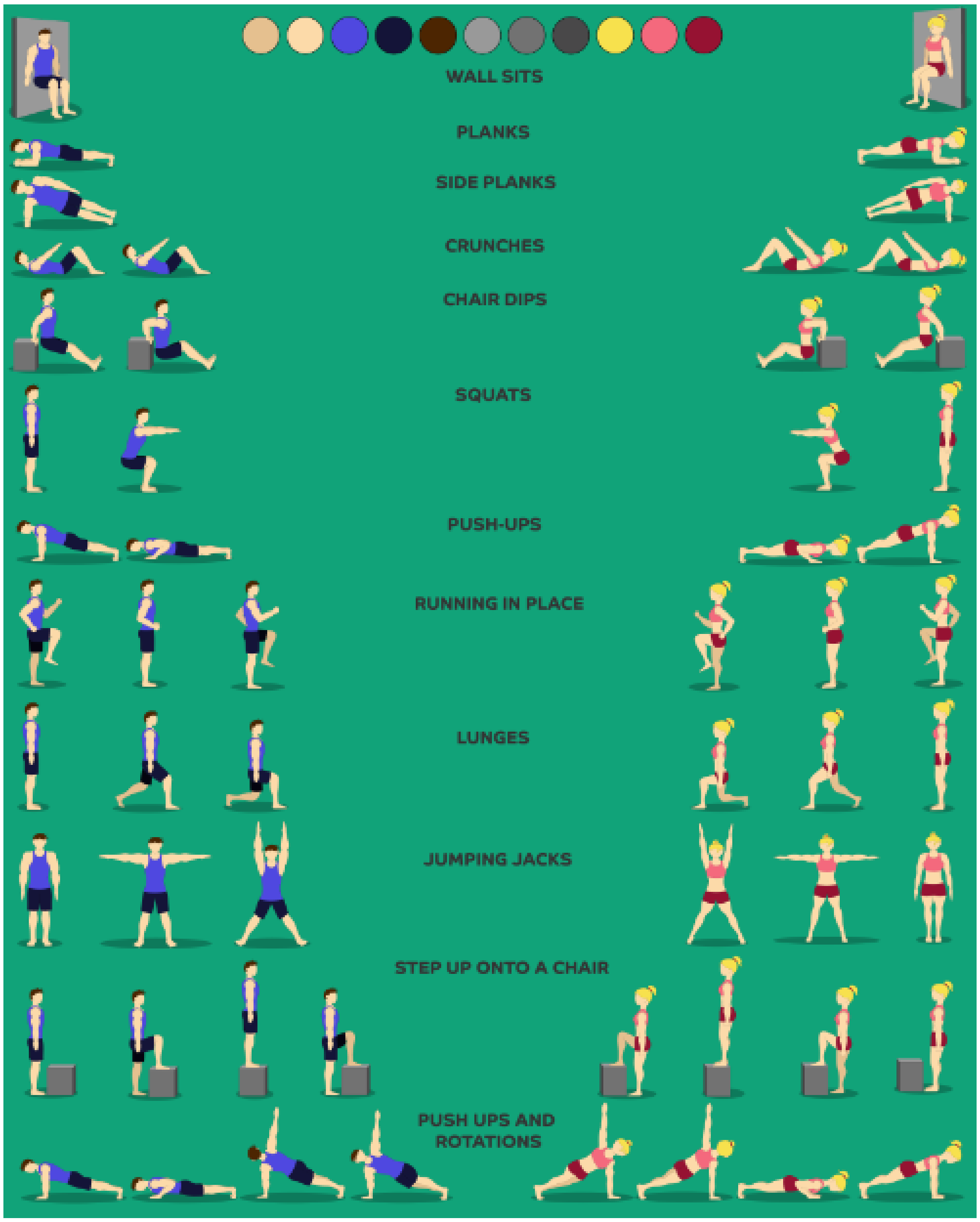

Figure C.1: Twelve exercise behavior models implemented in BEN'FIT. White males and female versions for the individualist culture. Correspondingly, black male and female versions were also implemented in BEN'FIT for the collectivist culture (not shown here).

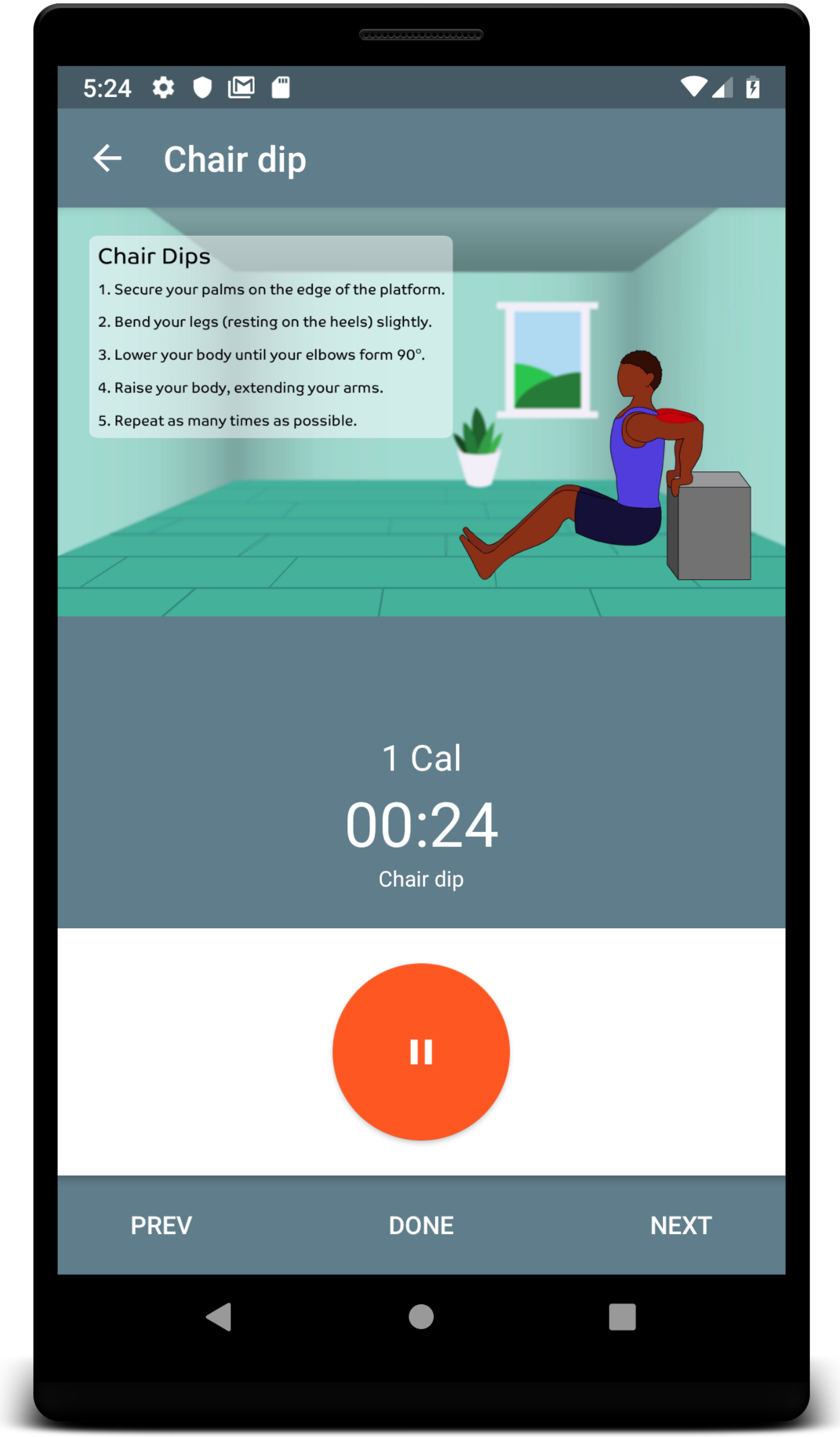

Figure C.2: Black male behavior model video and exercise (activity) timer

```xml
    <android.support.design.widget.AppBarLayout
        android:layout_width="match_parent"
        android:layout_height="wrap_content">

        <!-- The ActionBar displayed at the top -->
        <include
            layout="@layout/toolbar"
            android:layout_width="match_parent"
            android:layout_height="wrap_content" />

    </android.support.design.widget.AppBarLayout>
    <LinearLayout
        android:layout_width="match_parent"
        android:layout_height="match_parent"
        android:orientation="vertical">

        <LinearLayout
            android:layout_width="match_parent"
            android:layout_height="0dp"
            android:layout_weight="1"
            android:orientation="vertical">

            <VideoView
                android:id="@+id/video"
                android:layout_width="match_parent"
                android:layout_height="300dp"
                android:scaleType="centerCrop"/>

        </LinearLayout>

        <LinearLayout
            android:layout_width="match_parent"
            android:layout_height="wrap_content"
            android:layout_margin="20dp"
            android:gravity="center_horizontal"
            android:orientation="vertical">

            <TextView
                android:id="@+id/activity_calorie"
                android:layout_width="match_parent"
                android:layout_height="wrap_content"
                android:textAlignment="center"
                android:text="12 Cal"
                android:textSize="20sp"
                android:textColor="@color/mdtp_white"/>

            <TextView
                android:id="@+id/activity_duration"
                android:layout_width="wrap_content"
                android:layout_height="wrap_content"
                android:text="00:00"
                android:textSize="35sp"
                android:textAppearance="@style/TextAppearance.AppCompat.Large"
                android:textColor="@color/mdtp_white" />
            <TextView
                android:id="@+id/activity_name"
                android:layout_width="wrap_content"
                android:layout_height="wrap_content"
                android:text="Activity Name"
                android:textAppearance="@style/TextAppearance.AppCompat.Caption"
                android:textColor="@color/mdtp_white" />

        </LinearLayout>
```

Figure C.3: User interface code snippet for the behavior model video and exercise (activity) timer

```java
    private void buttonPlayerAction() {
        bt_play.setOnClickListener((arg0) → { startTimer(); });
    }

    private void startTimer(){
        if (!STARTED) {
            startActivity();
        } else {
            stopActivity();
        }
    }

    private String getTime(int time){
        int HOUR = 60 * 60;
        int remainder = time % HOUR;
        int mHour = (int) Math.ceil(time / HOUR);
        int MINUTE = 60;
        int mMin = (int) Math.ceil(remainder / MINUTE);
        int mSec = remainder % MINUTE;
        return decimalFormat(mMin) + ":" + decimalFormat(mSec);
    }

    private String decimalFormat(int val){
        return new DecimalFormat( pattern: "00").format(val);
    }

    private void finishedActivityButton(){
        stopActivity();
        AlertDialog.Builder builder = new AlertDialog.Builder( context: this);
        builder.setTitle(mCurrentActivity.getTitle());
        builder.setMessage("Are you sure you are done with this activity?" );
        builder.setPositiveButton("YES", new DialogInterface.OnClickListener() {
            @Override
            public void onClick(DialogInterface dialog, int which) {
                successButtonPressed();
            }
        });
        builder.setNegativeButton("NO", (dialog, which) → {
                startActivity();
        });
        builder.show();
    }

    private void navigate(int pos){
        if (pos < 11 && pos >= 0) {
            Intent intent = new Intent(getApplication(), this.getClass());
            intent.putExtra( name: "activity", MainActivity.ActivityList.get(pos));
            intent.putExtra( name: "pos", pos);

            this.finish();
            startActivity(intent);
        } else {
            Toast.makeText( context: this,  text: "Can't go further.", Toast.LENGTH_SHORT).show();
        }
    }

    private void successButtonPressed(){
        calculateTotalPoints();
        Intent intent = new Intent(getApplicationContext(), StartActivityCompleted.class);
        intent.putExtra( name: "pos", mActivityPosition);
        int calorie = Tools.activityCaloriesBurnt(weight,  min: (float) mTime/60);
        intent.putExtra( name: "calories", calorie);
        intent.putExtra( name: "points", totalPoints);
        startActivity(intent);
        finish();

        //update local active done
//      getSessionPoints();
        float done = preferences.getFloat(Constants.ACTIVE_LEVEL_DONE,  defValue: 0) + calorie;
        preferences.edit().putFloat(Constants.ACTIVE_LEVEL_DONE, done).apply();
        updateFirebaseActivity(calorie);
    }
```

Figure C.4: Logic code snippet for the behavior model video and exercise (activity) timer

Appendix D

Preselection of Pilot Participants

UNIVERSITY OF SASKATCHEWAN

Participant Consent Form

DEPARTMENT OF COMPUTER SCIENCE

You are invited to participate in our survey to recruit participants to use our fitness app for one month aimed at **motivating people to exercise regularly at home.**

Title: Recruitment of Participants for Research in Fitness App Testing

Ethics Application Number: BEH-1026

Researcher: Kiemute Oyibo, Computer Science, University of Saskatchewan, kso544@usask.ca
Supervisor: Julita Vassileva, Computer Science, University of Saskatchewan, jiv@cs.usask.ca
Researcher Assistants:
Olagunju Abdul-Hammid, Computer Science, University of Saskatchewan, aoo075@usask.ca
Barnabas Ifebude, Tenece Professional Services, Nigeria, barnabas.ifebude@tenece.com
Lee Cadotte, Undergraduate Summer student, University of Saskatchewan, lec337@usask.ca

Purpose(s) and Objective(s) of the Research:
The goal of this research is to recruit volunteers to participate in the actual use of our fitness app. To achieve this, we have designed a survey of 5 minutes that we need you to respond to prior to participating in the actual study (using the fitness app). Upon completing this current survey (https://www.surveymonkey.ca/r/PZ73VDQ) you will be compensated with N100 MTN recharge card.

Procedures: If you are interested in this study, click on "I consent" to answer the questionnaire. Upon completing it, you can optionally provide us with your email if you are interested in participating in the actual study (testing the fitness app). If you are shortlisted for the actual testing of our app, we will use the email you provided to send you a participation code and a link to download and install the app on your Android phone and necessary information about the study.

Potential Risks: There are no known or anticipated risks to you by participating in this survey.

Confidentiality: A university endorsed tool will be used for administering the survey. The data collected will be stored securely at Canadian Survey Monkey server and researchers' secure computers.

Right to Withdraw: Your participation is voluntary and you may withdraw from the survey at any point in the course of answering the questions. Your data shall be deleted and you will not be invited to participate in testing the fitness app. However, once you complete the survey, you can no longer withdraw.

Follow up: To obtain summary of the results from the study, please contact the researchers.

Questions or Concerns: Contact the researcher(s) using the information at the top of the page. This research project has been approved on ethical grounds by the University of Saskatchewan Research Ethics Board. Any questions regarding your rights as a participant may be addressed to that committee through the Research Ethics Office ethics.office@usask.ca (306) 966-2975. Out of town participants may call toll free (888) 966-2975.

Consent: By completing and submitting the questionnaire, **YOUR FREE/INFORMED CONSENT IS IMPLIED** and indicates that you understand the above conditions of participation in this study.

Figure D.1: Consent form for the preselection of collectivist participants recruited on social media

UNIVERSITY OF SASKATCHEWAN

Participant Consent Form

DEPARTMENT OF COMPUTER SCIENCE

You are invited to participate in our survey to recruit participants to use our fitness app for one month aimed at **motivating people to exercise regularly at home.**

Title: Recruitment of Participants for Research in Fitness App Testing

Ethics Application Number: BEH-1026

Researcher: Kiemute Oyibo, Computer Science, University of Saskatchewan, kso544@usask.ca
Supervisor: Julita Vassileva, Computer Science, University of Saskatchewan, jiv@cs.usask.ca
Researcher Assistants:
Olagunju Abdul-Hammid, Computer Science, University of Saskatchewan, aoo075@usask.ca
Barnabas Ifebude, Tenece Professional Services, Nigeria, barnabas.ifebude@tenece.com
Lee Cadotte, Undergraduate Summer student, University of Saskatchewan, lec337@usask.ca

Purpose(s) and Objective(s) of the Research:
The goal of this research is to recruit volunteers to participate in the actual use of our fitness app. To achieve this, we have designed a survey of 5 minutes that we need you to respond to prior to participating in the actual study (using the fitness app). Upon completing this current survey (https://www.surveymonkey.ca/r/PZ988F9) you will be compensated with US$ 0.5.

Procedures: If you are interested in this study, click on "I consent" to answer the questionnaire. Upon completing it, you can optionally provide us with your email if you are interested in participating in the actual study (testing the fitness app). If you are shortlisted for the actual testing of our app, we will use the email you provided to send you a participation code and a link to download and install the app on your Android phone and necessary information about the study.

Potential Risks: There are no known or anticipated risks to you by participating in this survey.

Confidentiality: A university endorsed tool will be used for administering the survey. The data collected will be stored securely at Canadian Survey Monkey server and researchers' secure computers.

Right to Withdraw: Your participation is voluntary and you may withdraw from the survey at any point in the course of answering the questions. Your data shall be deleted and you will not be invited to participate in testing the fitness app. However, once you complete the survey, you can no longer withdraw.

Follow up: To obtain summary of the results from the study, please contact the researchers.

Questions or Concerns: Contact the researcher(s) using the information at the top of the page. This research project has been approved on ethical grounds by the University of Saskatchewan Research Ethics Board. Any questions regarding your rights as a participant may be addressed to that committee through the Research Ethics Office ethics.office@usask.ca (306) 966-2975. Out of town participants may call toll free (888) 966-2975.

Consent: By completing and submitting the questionnaire, **YOUR FREE/INFORMED CONSENT IS IMPLIED** and indicates that you understand the above conditions of participation in this study.

Figure D.2: Consent form for the preselection of individualist participants recruited on Amazon Mechanical Turk

Appendix E

Invitation of Preselected Pilot Participants

Department of Computer Science
University of Saskatchewan

***BEN'FIT*: PILOTING OF HOME-BASED FITNESS APP**

You have been shortlisted to take part in the pilot study: *"**BEN'FIT:** **Using Home-Based Fitness App to become Active by Engaging in Regular Bodyweight Exercise**"*. Research shows that not so many people around the world are able to exercise regularly (e.g., by going to the gym), thereby exposing them to overweight, obesity and non-communicable diseases such as heart attack, hypertension, stroke, type 2 diabetes, etc. As a result, we have developed the *BEN'FIT* app to support your engagement in bodyweight exercise regularly in the comfort of your home. To participate in this pilot study, you will carry out the following:

1. Answer a 10-to-15-minute pre-intervention questionnaire sent to your Gmail account. Please kindly enter your participation code in the appropriate text box provided in the questionnaire prior to answering the questions.
2. Once you are done with the survey, download the *BEN'FIT app* (34 MB) from Google Play Store by using the provided link sent to your Gmail account. See the description of the app in the next page. Please ensure that the downloaded app, which features behavior models performing bodyweight exercises matches your race and gender. If not, inform the researcher at kiemute.oyibo@usask.ca.
3. After downloading the app, sign up using your Gmail account and **participation code as your username** to become a participant in the study. If you are concerned about privacy, we will advise that you create a new FAKE Gmail account using a username that does not identify you. You need the Gmail account to enable the app to use Google services, which it needs to function properly. The Google services will be hosted in United State and subject to its laws.
4. Find out about your weight and height prior to using the app. Entering wrong information will result in wrong computations of important metrics such as calories burned. If you don't know your weight and height and enter estimated information in the hope of exploring the app, finding about your weight and height later and updating this information, please let the researcher know at kiemute.oyibo@usask.ca so we disregard collected data prior to your entering the right weight and height information.
5. Use the app for a period of four weeks. The study officially begins 12 am the next day to your app download/installation date and ends on the 28th day (12 midnight). If you are using the social version, it officially begins the next day to the date the last person in the group downloaded/installed the app, at which time members of the group must have connected using the group code provided by the researcher. You can use the day you downloaded and installed the app on your Android phone to explore and get acquainted with it. **Kindly use the help menu item in the top-left corner of the main screen**.
6. Answer a post-intervention 10-to-20-minute survey (questionnaire). We will send you the link to the survey at the end of the four-week pilot study.

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Figure E.1: Pre-intervention instructions on the use of BEN'FIT (first page)

DESCRIPTION OF THE *BEN'FIT* APP

The *BEN'FIT* app is a fitness app that has been designed to encourage people, especially those who cannot go the gym quite often, to exercise at home regularly in order to meet the weekly target activity level (600 MET minutes – about 600 to 1000 burned calories depending on your weight) recommended by the World Health Organization. The app tracks your activity level by logging your daily/weekly bodyweight exercises and step counts and providing you with the calories burned for each and all performed activities. To enable you see how certain bodyweight exercises can be correctly performed, the app has provided you with a video demonstration of how these exercises (e.g., push-up, squat, etc.) can be performed. To use the app, you are expected to sign up using the participation code we have provide you. The following demographic information (age, gender, weight, height, country and race) would be collected to enable us to: (1) personalize the app to you; (2) calculate your calories burned; and (3) carry out data analysis for the different groups of people that would participate in the piloting of the app. So, please try and find out about your weight and height before the study begins. **In the course of using the app, we would like you to provide us with feedback about your exercise at least three times a week using the feedback functionality in the menu or "Well done!"/"Congratulations!" screen once you are done with a given workout session on a given day. Even on days you do not exercise, just writing "no exercise" and perhaps the reason you did not or could not exercise would help our research a long way.**

Finally, we will need you to be as honest as possible while using the app. Only track exercises you actually do. Anything otherwise will result in incorrect findings, which will not benefit research and the advancement of the body of knowledge.

In appreciation for your time, you will receive CAD $1 each for the pre-intervention and post-intervention studies. Moreover, if you participate in the four-week pilot of the app to the end, you will be compensated with CAD $1 per day of participation. You have a chance of being compensated with up to CAD $28. **In total, you can get up to CAD $30 if you complete all three studies.** We will send you the money using PayPal or other means possible.

For more information, questions about the study and problem with download/installation of the app, please contact and of the following phone number and/or email addresses:
Kiemute Oyibo or *Julita Vassileva*
at 306-966-2073 or kiemute.oyibo@usask.ca or *jiv@cs.usask.ca*

This study has been reviewed by, and received approval through, the Research Ethics Office, University of Saskatchewan.

UNIVERSITY OF SASKATCHEWAN | usask.ca

Figure E.2: Pre-intervention description of BEN'FIT (second page)

Department of Computer Science
University of Saskatchewan

EXLOGGER: PILOTING OF HOME-BASED FITNESS APP

You have been shortlisted to take part in the pilot study: *"**EXLOGGER:*** **Using Home-Based Fitness App to become Active by Engaging in Regular Bodyweight Exercise**". Research shows that not so many people around the world are able to exercise regularly (e.g., by going to the gym), thereby exposing them to overweight, obesity and non-communicable diseases such as heart attack, hypertension, stroke, type 2 diabetes, etc. As a result, we have developed the *EXLOGGER* app to support your engagement in bodyweight exercise regularly in the comfort of your home. To participate in this pilot study, you will carry out the following:

1. Answer a 10-to-15-minute pre-intervention questionnaire sent to your Gmail account. Please kindly enter your participation code in the appropriate text box provided in the questionnaire prior to answering the questions. **Skip this survey if you have done one before that required you to enter your participation code**.
2. Once you are done with the survey, download the *EXLOGGER app* (5 MB) from Google Play Store by using the provided link sent to your Gmail account. See the description of the app in the next page.
3. After downloading the app, sign up using your Gmail account and **participation code as your username** to become a participant in the study. If you are concerned about privacy, we will advise that you create a new FAKE Gmail account using a username that does not identify you. You need the Gmail account to enable the app to use Google services, which it needs to function properly. The Google services will be hosted in United State and subject to its laws.
4. Find out about your weight and height prior to using the app. Entering wrong information will result in wrong computations of important metrics which we need for our data analysis. If you don't know your weight and height and enter estimated information in the hope of exploring the app, finding about your weight and height later, please let the researchers know at kiemute.oyibo@usask.ca so they can update your information when you provide the actual one.
5. Use the app for a period of four weeks. The study officially begins 12 am the next day to your app download/installation date and ends on the 28th day (12 midnight). You can use the day you downloaded and installed the app on your Android phone to explore and get acquainted with it. **Kindly use the help menu item in the top-right corner of the main screen**.
6. Answer a post-intervention 10-to-20-minute survey (questionnaire). We will send you the link to the survey at the end of the four-week pilot study.

Figure E.3: Pre-intervention instructions on the use of EXLOGGER (first page)

DESCRIPTION OF THE *EXLOGGER* APP

The *EXLOGGER* app is a basic fitness app (journal app) that has been designed to encourage people, especially those who cannot go the gym quite often, to exercise at home regularly in order to meet the weekly target activity level (600 MET minutes – about 600 to 1000 burned calories depending on your weight) recommended by the World Health Organization. The app tracks your activity level by allowing you to log and view your daily/weekly bodyweight exercises and step counts. To use the app, you are expected to sign up using the participation code we have provide you. The following demographic information (age, gender, weight, height, country and race) would be collected to enable us to carry out data analysis for the different groups of people that would participate in the piloting of the app. So, please try and find out about your weight and height before the study begins. **In the course of using the app, i.e., logging your exercise and time spent on each activity (e.g., push-up, squat, crunch, jumping jack, etc.), we would like you to provide us with feedback about your exercise at least three times a week. Please use the timer to time her long you performed an activity. Even on days you do not exercise, just writing "no exercise," "0 minutes," and perhaps the reason you did not or could not exercise would help our research a long way.**

Finally, we will need you to be as honest as possible while using the app. Only track exercises you actually do. Anything otherwise will result in incorrect findings, which will not benefit research and the advancement of the body of knowledge.

In appreciation for your time, you will receive CAD $1 each for the pre-intervention and post-intervention studies. Moreover, if you participate in the four-week pilot of the app to the end, you will be compensated with CAD $1 per day of participation. You have a chance of being compensated with up to CAD $28. **In total, you can get up to CAD $30 if you complete all three studies.** We will send you the money using PayPal or other means possible.

For more information, questions about the study and problem with download/installation of the app, please contact and of the following phone number and/or email addresses:
Kiemute Oyibo or *Julita Vassileva*
at 306-966-2073 or kiemute.oyibo@usask.ca or *jiv@cs.usask.ca*

This study has been reviewed by, and received approval through, the Research Ethics Office, University of Saskatchewan.

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Figure E.4: Pre-intervention description of EXLOGGER (second page)

Appendix F

S4: Pre-Evaluation of Persuasive Health Application

UNIVERSITY OF SASKATCHEWAN

Participant Consent Form

DEPARTMENT OF COMPUTER SCIENCE

You are invited to participate in the four-week pre-intervention study prior to using our home-based fitness app to motivate individuals to exercise regularly.

Title: Piloting a Home-Based Fitness App to motivate Exercise Behavior: a Pre-Intervention Study

Ethics Application Number: BEH-1026

Researcher: Kiemute Oyibo, Computer Science, University of Saskatchewan, kso544@usask.ca
Supervisor: Julita Vassileva, Computer Science, University of Saskatchewan, jiv@cs.usask.ca
Researcher Assistants:
Olagunju Abdul-Hammid, Computer Science, University of Saskatchewan, aoo075@usask.ca
Barnabas Ifebude, Tenece Professional Services, Nigeria, barnabas.ifebude@tenece.com
Lee Cadotte, Undergraduate Summer student, University of Saskatchewan, lec337@usask.ca

Research Objective:
The goal of this research is to get your opinion on the fitness app you are about to use and your physical activity level prior to the actual use of the fitness app. To achieve this, we have designed a 10-to-15 minute survey that we need you to respond to prior to using actual the fitness app. Upon completing this current survey (https://www.surveymonkey.ca/r/PZ988F9) you will be compensated with CAD $1.

Procedures: If you are interested in this study, click on "I consent" to answer the questionnaire. You begin by entering your participation code in the text box provided. Your participation code will enable us to compensate you at the end of the piloting of the app. Thereafter, you will provide your response to questions about the fitness app design and your physical activity level.

Potential Risks: There are no known or anticipated risks to you by participating in this survey.

Confidentiality: A university-endorsed tool will be used for administering the survey. The data collected will be stored securely at Canadian Survey Monkey server and researchers' secure computers.

Right to Withdraw: Your participation is voluntary and you may withdraw from the survey at any point in the course of answering the questions. Your data will be deleted and you will not be able to participate in the piloting of the fitness app.

Follow up: To obtain summary of the results from the study, please contact the researchers.

Funding: The research is funded by Julita Vassileva's NSERC Discovery Grant.

Questions or Concerns: Contact the researcher(s) using the information at the top of the page. This research project has been approved on ethical grounds by the University of Saskatchewan Research Ethics Board. Any questions regarding your rights as a participant may be addressed to that committee through the Research Ethics Office ethics.office@usask.ca (306) 966-2975. Out of town participants may call toll free (888) 966-2975.

Consent: By completing and submitting the questionnaire, **YOUR FREE/INFORMED CONSENT IS IMPLIED** and indicates that you understand the above conditions of participation in this study.

Figure F.1: Consent form for the pre-evaluation of BEN'FIT

UNIVERSITY OF SASKATCHEWAN *Participant Consent Form*

DEPARTMENT OF COMPUTER SCIENCE

You are invited to participate in the pre-intervention study prior to using our exercise logger app to motivate yourself to exercise regularly for a four-week period.

Title: Pre-Intervention Study prior to using a Logger App to motivate Exercise Behavior

Ethics Application Number: BEH-1026

Researcher: Kiemute Oyibo, Computer Science, University of Saskatchewan, kso544@usask.ca
Supervisor: Julita Vassileva, Computer Science, University of Saskatchewan, jiv@cs.usask.ca
Researcher Assistants:
Olagunju Abdul-Hammid, Computer Science, University of Saskatchewan, aoo075@usask.ca
Barnabas Ifebude, Tenece Professional Services, Nigeria, barnabas.ifebude@tenece.com
Lee Cadotte, Undergraduate Summer student, University of Saskatchewan, lec337@usask.ca

Research Objective:
The goal of this research is to get your opinion on the exercise logger app you are about to use and physical activity level prior to the actual use of the app. To achieve this, we have designed a 10-to-15 minute survey that we need you to respond to prior to participating in the actual study (using the logger app). Upon completing this current survey (https://www.surveymonkey.ca/r/PZ988F9) you will be compensated with CAD $1. This will be included in your final compensation for participating in the testing of the app for a four-week period and sent to you through PayPal or otherwise.

Procedures: If you are interested in this study, click on "I consent" to answer the questionnaire. You begin by entering your participation code in the text box provided. Your participation code will enable us to compensate you at the end of the testing of the app. Thereafter, you provide your response to questions on the logger app and your physical activity level.

Potential Risks: There are no known or anticipated risks to you by participating in this survey.

Confidentiality: A university-endorsed tool will be used to administer the survey. The data collected will be stored securely at Canadian Survey Monkey server and researchers' secure computers.

Right to Withdraw: Your participation is voluntary and you may withdraw from the survey at any point in the course of answering the questions. Your data will be deleted and you will not be able to participate in the testing of the logger app.

Follow up: To obtain summary of the results from the study, please contact the researchers.

Funding: The research is funded by Julita Vassileva's NSERC Discovery Grant.

Questions or Concerns: Contact the researcher(s) using the information at the top of the page. This research project has been approved on ethical grounds by the University of Saskatchewan Research Ethics Board. Any questions regarding your rights as a participant may be addressed to that committee through the Research Ethics Office ethics.office@usask.ca (306) 966-2975. Out of town participants may call toll free (888) 966-2975.

Consent: By completing and submitting the questionnaire, **YOUR FREE/INFORMED CONSENT IS IMPLIED** and indicates that you understand the above conditions of participation in this study.

Figure F.2: Consent form for the pre-evaluation of EXLOGGER

Appendix G

S5: Evaluation of Persuasive Health Application

University of Saskatchewan

Participant Consent Form

DEPARTMENT OF COMPUTER SCIENCE

You are invited to participate anonymously in a research study entitled: **IN-INTERVENTION: Motivating People to Exercise Regularly at Home Using a Fitness App**

Researcher: Kiemute Oyibo, Computer Science, University of Saskatchewan, kso544@usask.ca
Supervisor: Julita Vassileva, Computer Science, University of Saskatchewan, jiv@cs.usask.ca
Researcher Assistants:
Olagunju Abdul-Hammid, Computer Science, University of Saskatchewan, aoo075@usask.ca
Barnabas Ifebude, Tenece Professional Services, Nigeria, barnabas.ifebude@tenece.com
Lee Cadotte, Undergraduate Summer Student, University of Saskatchewan, lec337@usask.ca

Purpose(s) and Objective(s) of the Research:
The goal of this research is to study users' **actual use** of a mobile fitness app called **BEN'FIT** to motivate their physical activity. The app helps users to set goals, track their step counts/ activities and perhaps collaborate with another user over a period of one month. Findings from this research shall be published in journal and conferences to advance the body of knowledge.

Procedures: We will log your use of the app, including your step count and activities (exercises) for a period of **one month**. At the end of this period, you will complete a 10-to-15-minute post-intervention questionnaire. We will send it to the email you provided or post it on Amazon Mechanical Turk for you to participate using the study code. Upon completion, you will be able to receive a compensation of up to **CAD $30 ($1 CAD for each day you have used the app). You may want to create a new Gmail account for the purpose of this study if you wish not to use your existing Gmail account.**

Potential Risks: There are no known or anticipated risks to you by participating in this research.

Confidentiality: Participants' data (step counts and activities) tracked by cloud-based Google Fit APIs, Firebase and Analytics will be encrypted. At the end of the study, the downloaded data will be stored securely stored in researcher's computers for data analysis.

Right to Withdraw: Your participation is voluntary and you may withdraw from the study at any point without giving a reason. You will only be compensated for the number of days you participated if you participated up to one week. If you complete the study, you can only withdraw (ask that your data be deleted) within the first week of completing the study.

Follow up: To obtain summary of the results from the study, please contact the researchers.

Questions or Concerns: Contact the researcher(s) using the information at the top of page 1. This research project has been approved on ethical grounds by the University of Saskatchewan Research Ethics Board. Any questions regarding your rights as a participant may be addressed to that committee through the Research Ethics Office ethics.office@usask.ca (306) 966-2975. Out of town participants may call toll free (888) 966-2975.

Consent: By using the app, **YOUR FREE/INFORMED CONSENT IS IMPLIED** and indicates that you understand the above conditions of participation in this study.

Figure G.1: Consent form for the evaluation of BEN'FIT in the field

UNIVERSITY OF SASKATCHEWAN

Participant Consent Form

DEPARTMENT OF COMPUTER SCIENCE

You are invited to participate in the testing of our home-based exercise logger app using your participation code.

Title: Motivating People to Exercise Regularly at Home Using a Logger App (BEH – 1026)

Researcher: Kiemute Oyibo, Computer Science, University of Saskatchewan, kso544@usask.ca
Supervisor: Julita Vassileva, Computer Science, University of Saskatchewan, jiv@cs.usask.ca
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Lee Cadotte, Undergraduate Summer Student, University of Saskatchewan, lec337@usask.ca

Research Objective
The goal of this research is to study the actual use of a mobile home-based exercise logger app called *EXLOGGER* aimed at motivating people to exercise regularly. The app helps users to log and track their daily exercises over a four-week period. It also automatically tracks their step count. Findings from this research will be published in journals and conferences to advance the body of knowledge.
Procedures: We will log your use of the app, including your step count and activities (exercises) and feedback over the four-week period. At the end of this period, you will complete a 10-to-15-minute post-intervention questionnaire. We will send it to the email you provided. Upon completion, you will be able to receive a compensation of up to CAD \$30 (CAD \$1 for each day you have used the app). You may want to create a new Gmail account for the purpose of this study if you wish not to use your existing Gmail account.
Potential Risks: There are no known or anticipated risks to you by participating in this research.

Confidentiality: Participants' data (step counts and activities) tracked by cloud-based Google Fit APIs, Firebase and Analytics will be encrypted. The Google services will be hosted in United States and subject to its laws. At the end of the study, the downloaded data will be securely stored in the researcher's computer for data analysis. Moreover, we will maintain a master list of participants' emails and participation codes for the purpose of compensation and accountability. This list will be maintained and securely stored in the researcher's computer.

Right to Withdraw: Your participation is voluntary and you may withdraw from the study at any point without giving any reason. You will be compensated based on the number of days you participated. If you complete the study, you can only withdraw (ask that your data be deleted) within the first week of completing the study.

Follow up: To obtain summary of the results from the study, please contact the researchers.

Funding: The research is funded by Julita Vassileva's NSERC Discovery Grant.

Questions or Concerns: Contact the researcher(s) using the information at the top of page 1. This research project has been approved on ethical grounds by the University of Saskatchewan Research Ethics Board. Any questions regarding your rights as a participant may be addressed to that committee through the Research Ethics Office ethics.office@usask.ca (306) 966-2975. Out of town participants may call toll free (888) 966-2975.

Consent: By using the app, **YOUR FREE/INFORMED CONSENT IS IMPLIED** and indicates that you understand the above conditions of participation in this study.

Figure G.2: Consent form for the evaluation of EXLOGGER in the field