Design and Evaluation of *COVID Pacman* – A Persuasive Game to Promote the Awareness and Adoption of COVID-19 Precautionary Measures Tailored to the Stages of Change

by

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DEDICATION

This thesis is dedicated to my mom's father
Late Mr. Chanderlal Gerela
He always inspired me to pursue my dreams.

I also want to dedicate this thesis to the love of my life "Shilpa Jadhwani" for her impeccable support and efforts to make me strong and stand with me like a shadow in every decision.

Finally, I want to thank my beloved parents for everything.

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ABSTRACT

Persuasive games are widely implemented in the healthcare domain to promote behaviour change among individuals. Previous research shows that using persuasive games results in increased motivation and awareness that led to a positive change in behaviour. However, there is little knowledge on which persuasive strategies will motivate people at different Stages of Behaviour Change and whether tailoring persuasive games to match user's stage of change will increase their effectiveness. To address this gap, we designed two different versions of a persuasive game using different persuasive strategies to target people at different stages change. The two versions of the game called COVID Pacman target the same goal of motivating the adoption of COVID-19 precautionary measures. The results of our study (N=127) followed by a semi-structured interview of 18 participants show that playing tailored persuasive game to individual's stages of change is effective as compared to playing non-tailored game.

LIST OF ABBREVATIONS USED

ANOVA	Analysis of Variance
RM - ANOVA	Repeated Measures Analysis of Variance
TTM	Transtheoritical Model
ARCS	Attention, Relevance, Confidence, Satisfaction
PSD Model	Persuasive System Design Model
R1	Research Question 1
R2	Research Question 2
R3	Research Question 3
R4	Research Question 4
R5	Research Question 5
IMI	Intrinsic Motivation Inventory
SD	Standard Deviation
MD	Mean Difference
WHO	World Health Organization
CDC	Center for Disease Control and Prevention
COVID	Corona (CO) Virus (VI) Disease (D)

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1 CHAPTER 1 INTRODUCTION

1.1 The Problem

Pandemics due to various infectious diseases with millions dying have been recorded in the history for the past several centuries [147]. The most well known in the history have been pandemic due to plague in Asia and several pandemics of influenza that killed millions of people. The pandemics continues in the current millennium too, and COVID-19 is the latest and certainly not the last pandemic. The unforeseen pandemic due to COVID-19 has challenged and exhausted the healthcare systems worldwide [142]. As of February 2021, Canada has 0.8 million confirmed cases and 21,395 recorded number of fatalities due to COVID-19. According to John Hopkins global virus tracker, United States of America (27.7 million), India (10.9 million), Brazil (9.9 million), United Kingdom (4.1 million), Russia (4.1 million) are the top 5 countries infected by the COVID-19 pandemic.

The COVID-19 pandemic has affected the world by causing devastating impacts on public health services and the global economy. According to John Hopkins University Center for System Science and Engineering (CSSE) [36], the latest emerging COVID-19 [149, 159] virus has already infected over 100 million people globally and over 2.4 million deaths in 194 countries as of February, 2021 [36]. Although the COVID-19 pandemic has crossed the one-year mark there are still rising cases in most parts of the world. According to WHO [155], this continued rise in cases is mainly due to community transmissions followed by cluster of cases in the different parts of the world. To curb this rapid spread of coronavirus, most countries around the world imposed strict public health guidelines and restrictions such as lockdowns. In addition to this, World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC) also proposed safety and precautionary measures [25, 158] to avoid contracting the COVID-19 and also reduce the spread of virus transmission. Also, with the emergence of new variants of the virus arising, reminds us that we all need to re-double our efforts to prevent the spread of COVID-19.

1.2 Motivation

Existing research [33], which consist of participants (n = 8317) from all around the world, also shows that following recommended health precautions (such as practicing social distancing, wearing face masks, and washing hands with soap/sanitizer) is an essential factor in defining behavioural interventions during COVID-19. On the other hand, 48.76% [67] of the individuals own a desktop/laptop worldwide, and 47.23% of the world population owns a smartphone, which are commonly used tools in previous studies [47, 143] to deliver behaviour change interventions. As a result, researchers are now focused on designing digital interventions for promoting desired behaviour changed among the wider audience.

Digital games are being widely used to deliver the behviour change interventions in our society. There is an increasing number of games that are targeted at solving problems in many domains including healthy eating [76, 113, 114, 122], sustainable environment [14, 64, 72, 99, 143], disease control [7, 20, 80, 89, 90, 102], and physical activity [26, 29, 45, 62, 85, 124]. Persuasive games in the health domain are designed as interventions that can motivate change of undesirable behaviours or promote desired behaviour in an intended way [117]. Prior studies [66, 113, 116, 117] have shown that persuasive games are effective tools for motivating desirable behaviour change. However, research has also shown that for persuasive games to be really effective, they need to be tailored to various individual characteristics [2, 118]. In line with this, research has shown that individual characteristics such as gamer types [115], personality type, and gamification user types are effective characteristics for tailoring persuasive games [116–118].

Despite this alarming spread of COVID-19 around the world and wide applications of behaviour change systems and persuasive games in health domains, there is little knowledge on how these persuasive games can be tailored to motivate people at various stages of change [133] to adopt the COVID-19 precautionary measures.

1.3 Solution

To bridge this gap, this research presents the design, development, and evaluation of *COVID Pacman*: A persuasive game to promote the adoption of COVID-19 precautionary measures tailored to stages of change. This arcade-style game simulates the transmission of COVID-19 virus and also offer suggestions to the players on how to take precautions against the virus. It engages

the player in an interactive manner using the various persuasive strategies, with the aim of imparting knowledge and promoting the adoption of COVID-19 precautionary measures, and hence motivating the desirable behaviour change. COVID Pacman was designed in two versions using different persuasive strategies in each. Both of the versions target the same goal of creating awareness and motivating people to adhere to the COVID-19 precautionary measures. We designed two versions to tailor the game based on the individual's stages of change. The game also uses the engaging concept of popular retro themed pacman game, making the players easy to learn and play, hence attractive to a wider audience.

We conducted a pre-test and post-test study involving 127 participants followed by a semi-structured interview of 18 participants to investigate the ability of the game to promote the motivation and change in behaviour by using different game versions for people at different stages of change.

1.4 Contributions

The thesis made two major contributions:

One, we successfully designed and developed two versions of the persuasive game called COVID Pacman that promotes the awareness and adoption of COVID-19 precautionary measures tailored to stages of change by only modifying the underlying persuasive strategies in each of the version. Designing two versions of the game using different persuasive strategies will be useful for researchers exploring the tailoring effects of persuasive strategies.

Two, we evaluated COVID Pacman on 127 participants. The results of the evaluations shows that overall COVID Pacman was effective with respect to promoting positive changes in *attitude*, *intention*, and *self-efficacy* of participants towards the adoption of COVID-19 precautionary measures. Attitude, intention, and self-efficacy are three direct predictors of behaviour [4].

The game led to a significant increase in *knowledge* about COVID transmission, symptoms, preventive measures, virus lifecycle, and susceptibility. The results of the evaluation showed that participants who played the version of the game tailored to their stages of change, found the game to be more effective as compared to non-tailored version. Moreover, our findings also revealed that the players who played the tailored version of the game had a positive experience (*play*

experience) as compared to those who played the non-tailored version. Finally, the players found the game to be persuasive as shown by the overall *persuasiveness* measure.

1.5 Overview of Thesis

This thesis contains a detailed description of all the work carried out during the design, development, and evaluation of COVID Pacman intervention, in a sequence of 6 chapters.

CHAPTER 1 INTRODUCTION: This chapter introduces the thesis. It states the problem and the issues surrounding the problem addressed in the thesis.

CHAPTER 2 RESEARCH BACKGROUND: This chapter contains a review of research related to this thesis. We review our theoretical foundation, literature on persuasive strategies and deconstruct how they have been applied in persuasive games design. We also present the comparative effectiveness of persuasive strategies across multiple domains. Finally, we conclude with a review of work on personalizing and tailoring persuasive games. It also presents a review of 61 persuasive games, over the span of 19 years (2001 – 2020) and classifies them into 6 sub-domains: Health and Nutrition, Physical Activity, Dental, Disease Prevention, Sustainable Development and Miscellaneous. It also presents an analysis of these games by their platforms, year, country of research and their study details.

CHAPTER 3 COVID PACMAN DESIGN AND IMPLEMENTATION: This chapter describes the iterative process taken in the design and development of COVID Pacman for both versions. We also present the details about the implementation of persuasive strategies employed in both versions of COVID Pacman.

CHAPTER 4 COVID PACMAN PERSUASIVE GAME EVALUATION: This chapter contains the details about the evaluation of COVID Pacman. It also presents the research questions and the detailed user study process.

CHAPTER 5 STUDY RESULTS: This chapter presents the detailed data analysis and results of the study.

CHAPTER 6 DISCUSSION: This chapter discuss about the implications of the results.

CHAPTER 7 CONCLUSION: This chapter summarizes the entire work and presents the future research directions.

2 CHAPTER 2 RESEARCH BACKGROUND

Persuasive systems are referred as computerized software or information systems designed to reinforce, change, or shape attitudes or behaviours or both without using coercion or deception [109]. According to Fogg [59], persuasive systems are systems that motivate people to change their behaviours or attitudes without using coercion or deception [59]. Persuasive system comes in various forms. They could be websites, standalone systems (e.g., desktop applications), virtual reality systems, or games. Due to the motivational pull that games offer, they are increasingly becoming the preferred and popular medium to deliver the persuasive contents that can motivate behaviour change.

Persuasive games are known to have the ability to motivate the behaviour change in a subtle way, while the player is having fun. Persuasive games are designed as interventions with the primary purpose of encouraging healthy behaviour change [117]. Persuasive games are, therefore, defined as games that are intentionally designed to motivate players to change their attitudes of behaviours [22, 114] using various persuasive strategies. Over the years, various persuasive games have been developed to change, modify, or reinforce human behaviour. Previous studies have shown that persuasive games are effective in motivating desired behaviour change in a variety of health domains such as physical activity [18, 125], healthy eating [113, 114], smoking cessation [93], and general wellbeing [32]. However, there is very little research on designing and evaluating a persuasive game targeted at infectious disease. Therefore, this study focuses on designing and evaluating COVID-Pacman, a persuasive game for motivating people to adhere to the COVID-19 precautionary measures.

In this section, we review our theoretical foundation, we also review literature on persuasive strategies, deconstruct how they have been applied in persuasive games design and present a comparative analysis of effectiveness of persuasive strategies across domains. we conclude with review of work on personalizing and tailoring persuasive games.

2.1 Persuasive Games

According to Fogg [60], one of the steps to developing an effective persuasive system is finding relevant examples of persuasive technology. These examples would help to understand what has been successful in that past and what has not, thereby assisting in avoiding previous mistakes by

researchers in the field. The relevant examples of persuasive technology for the current research are "Persuasive Games." Therefore, to fully understand the research area, I reviewed existing research in the area of persuasive games. To collect relevant papers, I searched popular databases including ACM Digital Library, IEEE, and Springer. I also searched Google Scholar as a secondary source for any paper we may have missed.

I used the keywords '*Persuasive Games*', '*Behaviour change games*', and '*Games for change*.' Initially, we reviewed paper titles, abstracts, and introductions of each retrieved paper, for papers focusing on the design or study of a persuasive game. In total, we were able to extract 219 papers for this purpose. We skimmed through each selected paper to eliminate papers that didn't meet our inclusion criteria. Our inclusion criteria were: (1) The paper is not a systematic review paper (identified from title), (2) The paper is about the implementation of a game (identified from abstract), (3) If the paper is not a duplicate of an already chosen paper.After going through all the papers, we removed 158 that didn't meet the inclusion criteria which left us with 61 papers. Therefore, in total, we reviewed 61 papers on persuasive game design and evaluation.

I reviewed the 61 papers and coded them using the coding scheme developed and adapted from Orji and Moffat [120]. I analysed each paper under the following categories: year of the research, the sub-domain, game title, the technology used, persuasive strategies used, the method of evaluation, the duration of the study, the main persuasive strategies used, the venue of publication, the effectiveness of their findings, and the countries of the target audience. Figure 2.1 shows the process flow for the inclusion of papers in our literature review.

From our analysis, we classified persuasive games into six major domains: Healthy eating and nutrition, Physical activity, Dental, Disease prevention and management, Sustainable development, and Miscellaneous.

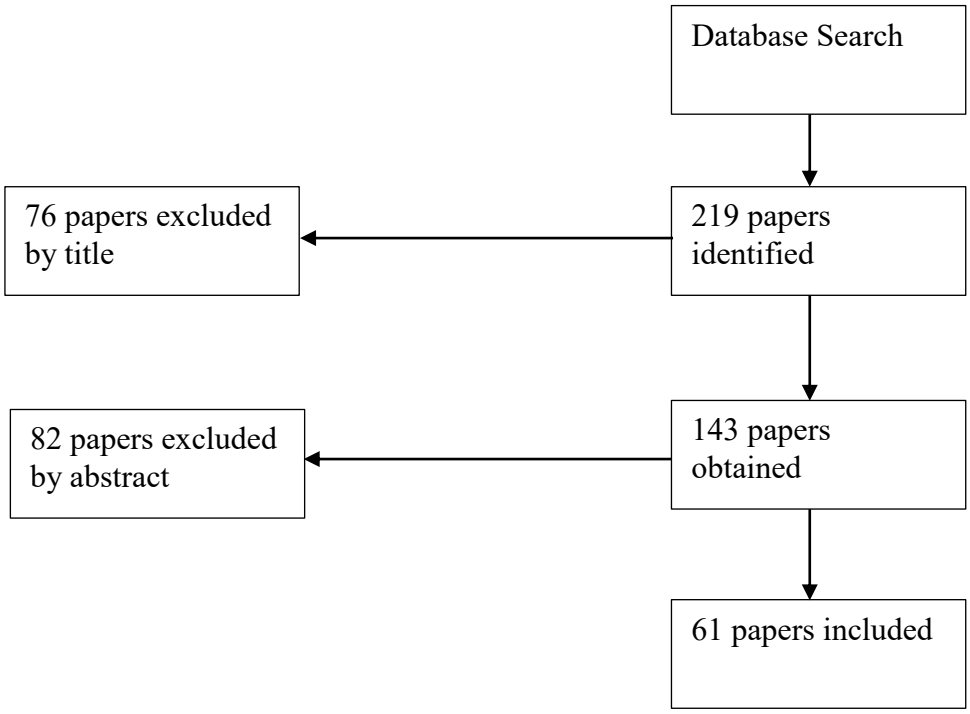


Figure 2.1: Study Identification Papers

2.2 Persuasive Strategies Employed

A fundamental feature for behaviour change games is the use of persuasion to influence or reinforce behaviours, attitudes, feelings, or thoughts [94]. Persuasion is achieved by intentionally implementing various persuasive strategies. Over the years, many researchers have proposed multiple persuasive strategies. For example, Fogg's proposed seven persuasive technology tools [61], Cialdini et al.'s 6 principles of persuasion [31], and Oinas-Kukkonen et al.'s 28 persuasive strategies, also known as PSD (Persuasive System Design) model [109]. Using our coding sheet, we identified the frequency of persuasive strategies implemented in the persuasive games collected from our literature survey as shown in Figure 2.2.

Our analysis results show that rewards (n=28) followed by competition and comparison (n=11), suggestion (n=10), and self-monitoring (n=9) are the most implemented persuasive strategies in the persuasive games over the years to encourage behaviour change. These results are in line with previous studies [113, 116], which also found that reward, suggestion, competition and

comparison, and self-monitoring are among the most commonly employed persuasive strategies in the games for behaviour change. Therefore, for our work, we are targeting these four persuasive strategies. Table 2.1 shows the definition of these four persuasive strategies adapted from [113].

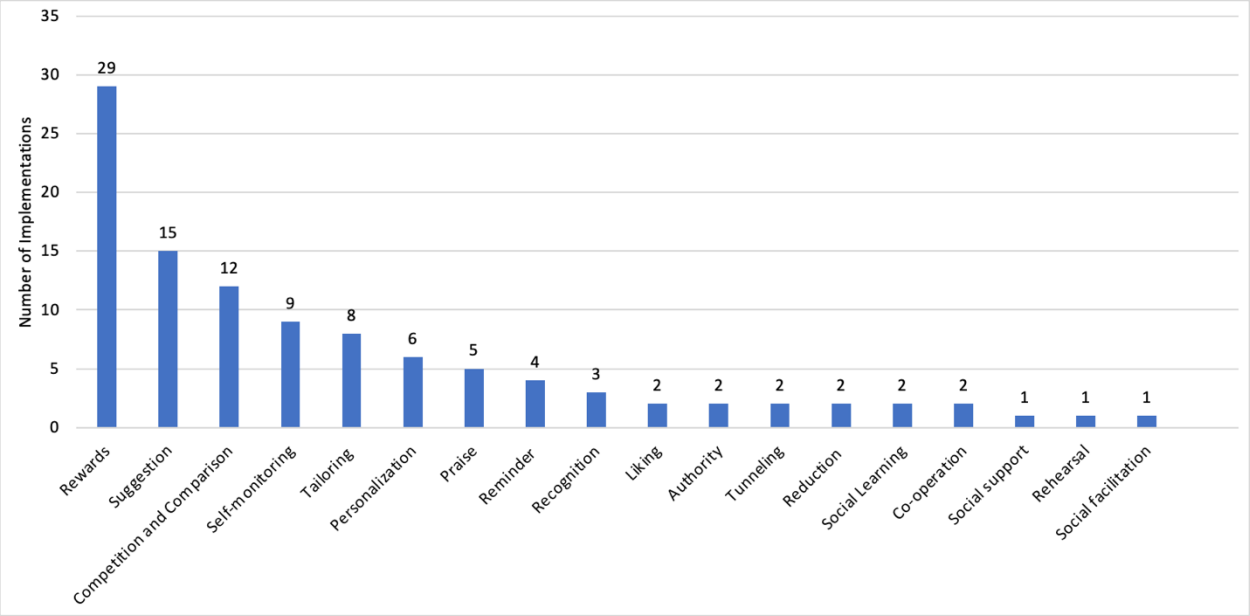


Figure 2.2: Frequency of persuasive strategies implemented in the persuasive games from literature survey

Table 2.1: Definition of Persuasive Strategies

Persuasive Strategy	**Definition**
Reward	Offers virtual rewards to users for performing the target behaviour
Suggestion	Provides fitting suggestions (e.g., providing calorie intake suggestions in a healthy eating app) for achieving the desired behaviour during system use
Competition and Comparison	This strategy allows the users to compete with each other to perform the desired behaviour and a means for the user to view and compare his/her performance with the performance of other user(s)
Self-monitoring	Provides means for users to track their own progress or performance while performing the behaviour.

2.3 Operationalization of Persuasive Strategies in Persuasive Games

Our review of related work reveals various ways in which persuasive strategies were operationalized in behaviour change games across multiple domains. In the following section, we describe how researchers implement the four strategies considered in this thesis in behaviour change games in the health domain.

2.3.1 Implementation of Persuasive Strategies in Healthy Eating and Nutrition Games

This groups of persuasive games are designed to motivate people to eat healthily. The games that we identified in this category are: 'Hungry Panda 2 [86]', 'Playful Bottle [30]', 'Order Up [71]', 'Time to Eat [130]', 'The smart lunch tray [97]', 'Right way café [127]', 'Squire's Quest [15]', 'Lunch Time [114]', 'MunchCrunch [100]', 'JunkFood Aliens [113]'.

One of the games is Lunch Time [114], a persuasive game for motivating healthy eating. Lunchtime employs *reward*, *competition* and *comparison* strategies. In this game, players play the role of a restaurant visitor, and the goal is to choose the healthiest option from the list of food choices. Players are awarded points (*reward*) for making healthy food choices, and every player is allowed to view and compare (*competition* and *comparison*) their points with other players. Right way café [127] is another persuasive game to promote healthy eating and physical activity [127]. This game provides healthy eating *suggestions* based on the player's avatar physical attributes (age, gender, and physical activity). The player who best managed their avatar's health with daily diet wins the game (*competition*).

2.3.2 Implementation of Persuasive Strategies in Physical Activity Games

Within this category, there are games that motivate people to be physically active. The games that we identified in this category are: 'Tree Care [124]', 'P.H.A.N.T.O.M [85]', 'NEAT-o-Games [63]', 'LocoSnake [29]', 'SP-Stretch [27]', 'UKKO [45]', 'Fish n Steps [96]', 'Dance Dance Revolution [78]', 'Climb the world [3]', 'Ere be Dragons [39]', and one another game with no title [12].

TreeCare is a persuasive mobile game for promoting physical activity and reducing sedentary behaviour [124]. In this game, the growth of a tree is tied to the player's physical activity in real-world. They employed *rewards* as virtual trophies in the game, *self-monitoring* as a daily step counter for the player, and *competition/comparison* as leaderboard. Another example is 'fish n steps' [96] which is a PC based game to motivate physical activity among the users. In the game,

the growth of the fish (which is virtual character of the player) is attached to the players' daily step goals. They employed *rewards* as fish growth and baby fishes when a target step count is reached, *self-monitoring* as progress bar for daily step counter for the player, *competition* as leaderboard to compare the performance with other players.

2.3.3 Implementation of Persuasive Strategies in Dental Health Games

Within this category, there are games that motivate people to practice better dental hygiene. We have identified three games in this category: They are 'Sugargotchi' [70], 'Molarcropolis' [145] and one another game with no name [83].

Sugargotchi [70] is a pet based digital game in which the state of the players' dental health is represented through color and energy of the digital pet. This game targets on increasing child's interest and awareness of their current dental health, role of free sugar in tooth decay and suggestions to improve their dental health. They employed *suggestions* in which the pet gives feedback to players to improve their dental health. Moreover, they also employed *rewards* in which the digital pet changes color to green and whistles when the dental hygiene is good. Another game is molarcropolis [145] which is persuasive mobile game to raise oral health and dental hygiene awareness. They employed *suggestions* strategy to make the game informative by presenting the information on various aspects of oral health and dental hygiene.

2.3.4 Implementation of Persuasive Strategies in Game to Promote Disease Prevention

This category contains persuasive games designed to motivate people to carry out the behaviors that can prevent the acquisition of diseases. Our research problem is a subset of this category because we are designing and evaluating a persuasive game to promote awareness and adoption of COVID-19 precautionary measures (infectious disease). The games identified in this category are: 'MACO' [7], 'Wee Willie Wheezie' [81], 'Remission' [89], 'MyPyramid Blast-Off [102]', 'Packy and Marlon [20]', 'What Remains?' [24], 'Bronkie the Bronchiasaurus' [82], 'Tumaini' [157], 'Slime-O-Rama' [161], 'STD PONG' [106], 'Clot Buster' [156], 'Birthday Party' [65], 'Smoke Screen' [128], 'Play Forward: Elm City Stories' [58], ZIG-ZAIDS [139], web-based game for HIV prevention [50], Plants vs Zombies [101], Dr. Luden's LSG [98] and one game [108] to convey the importance of influenza vaccination.

STD PONG [106] is a mobile based arcade style game promoting safe sexual behaviours among young adults in Africa. The game simulates various sexual risky behaviours that could lead to

contracting STDs and HIV and how to avoid them. They employed *rewards* by allowing the players to collect powerups (e.g., condoms) to fight the STD and HIV monsters. Moreover, they also employed *suggestions* by providing information about the use of each powerup, *self-monitoring* by highlighting the health bar of the player, and *competition and comparison* by using leaderboard to allow players to compare their progress with others. Plans vs Zombies [101] is another game promoting the preparedness and use of vaccinations during an epidemic. In this game, the player gets a zombie avatar. Once, they get the vaccinations they will get the *rewards* in the forms of the badges on the arms of their avatar. They also implemented the suggestions persuasive strategy in the game by providing the knowledge about the public health guidelines. Similarly, Nowak et al. [108] also developed a virtual reality story based education game to promote the importance of vaccination for influenza epidemic. They used suggestions persuasive strategy in various forms to study the effects of education on participant's behaviour towards vaccination.

Another game called Bronki the Bronchiasaurus [82] is a persuasive game which helps young children with asthama in monitoring their self-management skills. The players have to protect their in-game characters from dust and smoke while they go on a quest by measuring and monitoring their breath strength (*self-monitoring*). The good health outcome of the in-game character makes the player win the game (*competition*). The examples of the games discussed above show how game interventions can be implemented using persuasive strategies to motivate preventive health behaviour and disease management.

2.3.5 Implementation of Persuasive Strategies in Games to Promote Sustainable Environment

This category contains persuasive games that motivate people to conserve natural resources such as games that promote saving electricity or proper disposal of wastes. The games identified in this category are: 'Energy Life' [64], 'Power Agent' [72], 'Power Explorer' [14], 'LEY' [99], 'Powerhouse' [135], 'Stop Disasters!' [151], 'Shrub Battle' [40], 'Energy Wars' [154], 'Play & Go' [55], and one game with no name [34].

Play & Go [55] is an urban game whose main goal is to promote, by virtual and real incentives, a voluntary behaviour change towards a more sustainable mobility habits [55]. They implemented *rewards* in the form of points, badges earned for using the sustainable transport for trips. Moreover, they also employed *self-monitoring* as a diary tracker to track the trips, and *competition and*

comparison by utilizing leaderboards. Stop Disasters! [151] is a web-based persuasive game created by the UN Office for Disaster Risk Reduction. This game was created to help create awareness and motivate people to behave appropriately during natural disasters. It simulates different cities in the world and the disasters that they are prone to. The player picks a city and is given the responsibility to save the lives of members of the city from its corresponding natural disasters like a tsunami, hurricane, wildfire, earthquake, or flood by providing defences and optimally upgraded housing. The game shows the cities' population and budget, while the player has to manage the budget wisely on materials that would protect the city from the impending disaster. They employed *suggestions* in the game as a learning and awareness tool to impart knowledge on the players about various disasters.

2.3.6 Implementation of Persuasive Strategies in Games for Miscellaneous Purposes

Some fields of behaviour change were grossly underrepresented in the papers we extracted for this literature review. We classified these papers under miscellaneous purposes. The game identified in this category are: 'Zombie division' [84], 'EMSAVE' [23], 'Spent' [137], 'MoviPill' [110], 'REXplorer' [126], 'PeaceMaker' [6], 'Phisher Crush' [104], Birthday Party [66], and one game with no name [141]. The main focus of games in this category was providing awareness of the target behaviour across multiple domains (e.g., education for online security and privacy, attitude change for homeless people, etc.)

Phisher crush [104] is the mobile persuasive game that promotes online security by educating people on how to detect and avoid phishing links and emails. The primary task of this game is for the player to match pairs of correct hyperlinks or email addresses as fast as possible. They employed *rewards* in the form of points for correct matches and badges for achieving different milestones. Moreover, they also implemented *suggestions* by providing information on how phishing links and emails looks like, how to identify the malicious links and email addresses.

MovPill [110] is another game that persuades patients to be more compliant with their medical prescriptions. The game tries to persuade these patients to take their medications at the right time, as prescribed by the doctor. This game is targeted at the elderly, who have the tendency of forgetting to take their medication. When players take their medication on or close to the time prescribed by the doctor, they earn points (*rewards*). These points are determined by using a sensor attached to the inner part of the pillbox that the player uses to store his pills. At the end of each

week, the game displays the player with the highest points as the winner of the game (*competition and comparison*), then restarts the tracking for the new week.

Table 2.2: Summary of Persuasive Strategies Implementation in Persuasive Games

Persuasive Strategy	**Implementations**
Rewards	Coins, Trophies, Badges, Color cues, Points
Suggestion	Educating users by providing information regarding the behaviour
Self-monitoring	Health bar, Progress bar, Diary tracker
Competition and Comparison	Leaderboards

Table 2.3: Summary of Persuasive Strategies Implementation Across Domains

Domain	**Rewards**	**Suggestion**	**Self-monitoring**	**Competition /Comparison**
Health and Nutrition	Game points for healthy eating choices	Suggestions to players for healthy eating based on their demographics	Tracker of calories consumed over the period of time	Leaderboard to compare the points
Physical Activity	Virtual trophies and points for daily goal	-	Tracker for Daily step counter	Leaderboard to compare step counter
Dental Health	Color cues for virtual pet	Feedback to improve dental health	-	-
Disease Prevention	Powerups or points as rewards	Providing information for the target behavioir	Health bar to track the target behaviour	Leaderboard to compare the points

Sustainable Environment	Points and badged for achievements	Providing information for the target behavioir	Diary to track the target behaviour	Leaderboard to compare the points
Miscellaneous Purposes	Points and badged for achievements	Providing information for the target behavioir	Health Bar or tracker to track the target behaviour	Leaderboard to compare the points

The examples of the games discussed above show how game interventions can be implemented using persuasive strategies to motivate various behaviours in the area of healthy eating, physical activity, dental health, disease prevention and management, sustainable environment, and several other miscellaneous purposes. However, most of the games follow the one-size-fits-all approach in their design, even though research has shown that players differ in both behaviour and motivation [117]. Although some of the games tailored their recommendations based on user's characteristics (e.g., weight, height), none of the games tailored the underlying persuasive strategies based on the individual's stages of change. [113]. Research has shown that using an inappropriate strategy can constitute a major barrier to behaviour change [87]. Empty cells in the Table 2.3 show that there was no implementation of that persuasive strategy for the domain.

2.4 Comparative Effectiveness of Persuasive Strategies across Domains

Previous research has highlighted the fact that the effectiveness of persuasive strategies could be influenced by many factors including the choice of persuasive strategies and their operationalization in the persuasive intervention [10, 54]. Below, we review the effectiveness of persuasive strategies across different domains based on existing literature. Strategies perceived to be effective by the participant (in the study conducted) are highlighted with '+' sign in Table 2.4, while strategies found to be not effective are highlighted with '-' sign. Table 2.4 compares the effectiveness of the five persuasive strategies used in this research across multiple domains and established that effectiveness of the strategies in fact varies across domains, hence the need to investigate their effectiveness in the domain of diseases prevention.

Table 2.4: Comparing Effectiveness of Persuasive Strategies across Domains

Persuasive Strategies	**Author**	**Domain**	**Effectiveness**
Rewards	Munson et al. [103]	Physical Activity	-
	Hsu et al. [79]	Healthy Eating	+
	Schnall et al. [140]	Disease Management (for HIV patients)	+
	Baskerville et al. [16]	Smoking Cessation	+
	He et al. [75]	Sustainable energy consumption	+
	Ferron et al. [54]	Sustainable transport and mobility	-
	Nkwo el al. [107]	E-commerce	+
Suggestion	Latimer et al. [17]	Physical Activity	-
	Toscos et al. [150]	Healthy Eating	+
	Schnall et al. [140]	Disease Management (for HIV patients)	+
	Baskerville et al. [16]	Smoking Cessation	+
	He et al. [75]	Sustainable energy consumption	+
	Ferron et al. [54]	Sustainable transport and mobility	+
	Nkwo el al. [107]	E-commerce	+
Self-monitoring	Munson et al. [103]	Physical Activity	+
	Hsu et al. [79]	Healthy Eating	+
	Schnall et al. [140]	Disease Management (for HIV patients)	+
	Baskerville et al. [16]	Smoking Cessation	+

	He et al. [75]	Sustainable energy consumption	+
	Ferron et al. [54]	Sustainable transport and mobility	+
	Nkwo el al. [107]	E-commerce	+
	Burke et al. [21]	Weight Loss	-
	Orji et al. [119]	Overall Health and Wellness	-
Competition/Comparison	Almutari et al. [8]	Physical Activity	+
	Toscos et al. [150]	Healthy Eating	+
	Zechmann et al. [153]	Disease Management (for patients with chronic heart disease)	+
	Baskerville et al. [16]	Smoking Cessation	-
	He et al. [75]	Sustainable energy consumption	+
	Ferron et al. [54]	Sustainable transport and mobility	-
	Nkwo el al. [107]	E-commerce	+

As shown in Table 2.4 above, the effectiveness of persuasive strategies varies across domains. For example, the implementation of rewards as badges, trophies, and icons was found to be effective in motivating the behaviour change in the healthy eating [79], E-commerce [107], disease management (for HIV patients) [140], sustainable energy consumption [75], and smoking cessation [16] domains.

However, according to Munson et al. [103] rewards were not effective in motivating the participants with respect to encouraging them to be physically active. Also, Ferron et al. [55] found in their evaluation that badges and points (rewards) were not effective in motivating sustainable mobility and transport. Similarly, Latimer et al. [17] found suggestions as ineffective when implemented as feedback messages on the participant's behaviour. However, it was found to be effective in the domain of healthy eating [150], E-commerce [107], disease management (for HIV

patients) [140], sustainable energy consumption [75], sustainable transport and mobility [55], and smoking cessation [16].

On the other hand, employing competition/comparison as a leaderboard was perceived to be effective in promoting physical activity [8], E-commerce [107], sustainable energy consumption [75], disease management (for patients with chronic heart disease) [153], and healthy eating [150]. However, according to Baskerville et al. [16], competition/comparison was not effective in promoting smoking cessation as the participants preferred their progress to be private and anonymous. Ferron et al. [55] also found leaderboards as one of the reasons for the participants' demotivation and quitting the game. The implementation of self-monitoring strategy for tracking the behaviour of the people and allowing them to visualize their progress was effective in promoting physical activity [103], healthy eating [79], disease management (for HIV patients) [140], smoking cessation [16], sustainable energy consumption [75], sustainable transport and mobility [55], and e-commerce [107]. However, in weight loss [21] and overall health and wellness [119] domains, self-monitoring was found to be ineffective.

Therefore, the effectiveness of the persuasive strategies seems to be domain dependent. In other words, the effectiveness of persuasive strategies varies across domains. Hence, there is a need to study and evaluate the effectiveness of persuasive strategies in the domain of infectious diseases, specifically COVID-19 on the general audience which has not been investigated by any research to the best of our knowledge.

2.5 Discussion of Related Work

Based on the analysis of the 56 papers, we were able to draw some insights and conclusions on the trends in the area of Persuasive Games.

2.5.1 Persuasive games by Platform

From Figure 2.3, we can see that mobile and PC are the most frequently used platforms in the persuasive game development. This is understandable because according to Oinas-Kukkonen [109], for any persuasive technology to be successful, they should always be present. Therefore, it makes sense to target mobile and PC users as they contribute to majority of the platforms which people own in their house.

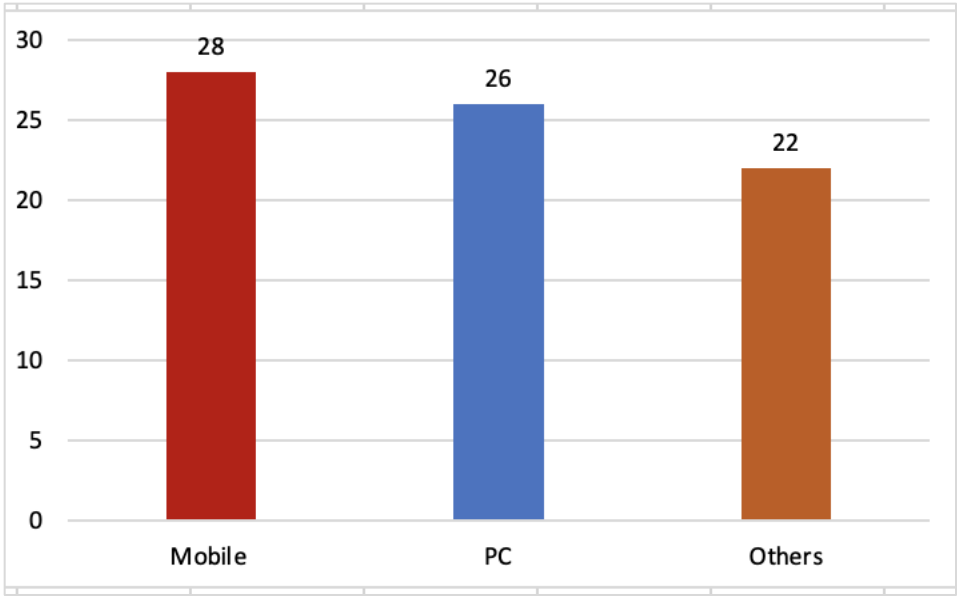


Figure 2.3: Persuasive Games Frequency by Platform

2.5.2 Persuasive games by Year and Country

We analyzed the persuasive games implemented by years to explore if there has been variation in the implementation of persuasive game over the years. Further, we also explored the variation in the implementation of persuasive games across the different countries. Based on our analysis, of 19-year period, from 2001 to 2020, persuasive games were implemented in various countries over the years. Figure 2.4 shows that USA is leading country with most research at 32%, followed by Canada with 11%, Taiwan, Italy, and UK share the third position with 7%.

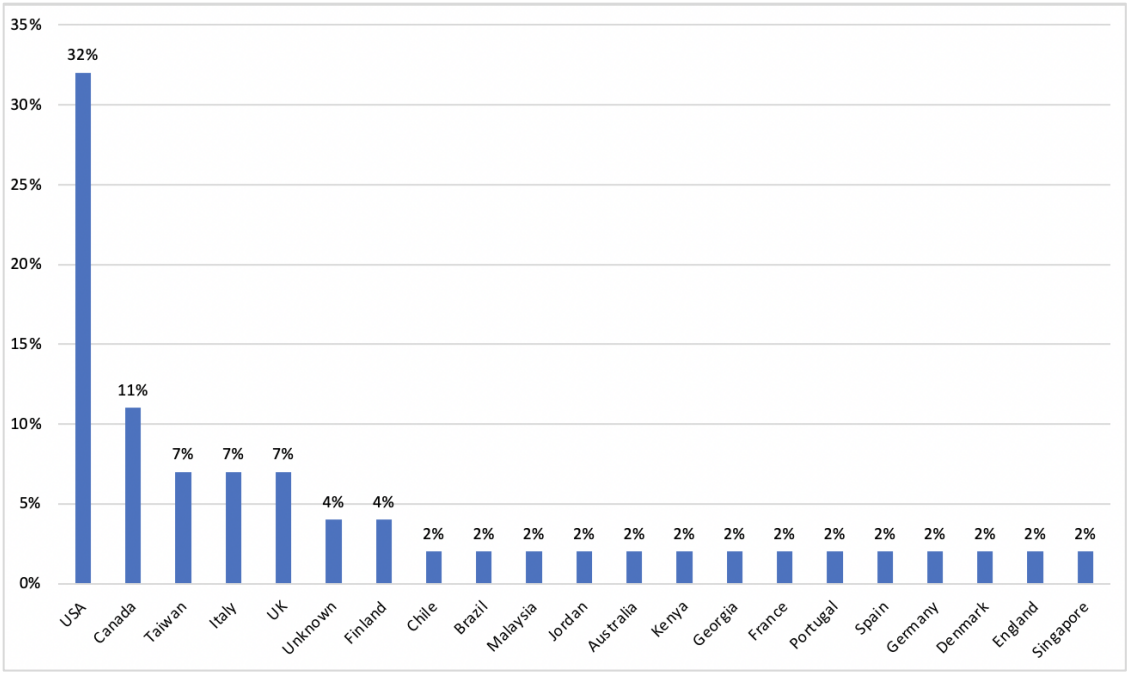


Figure 2.4: Persuasive Games by Country

Also, Figure 2.5, shows the percentage count for the number of persuasive games being implemented over the years. This shows that the persuasive games for motivating behaviour change have been gradually increasing their prevalence. Therefore, in line with previous research [73, 74, 121], we can say that from various available persuasive systems; persuasive games are now amongst the most popular and effective tool for designing behaviour change interventions.

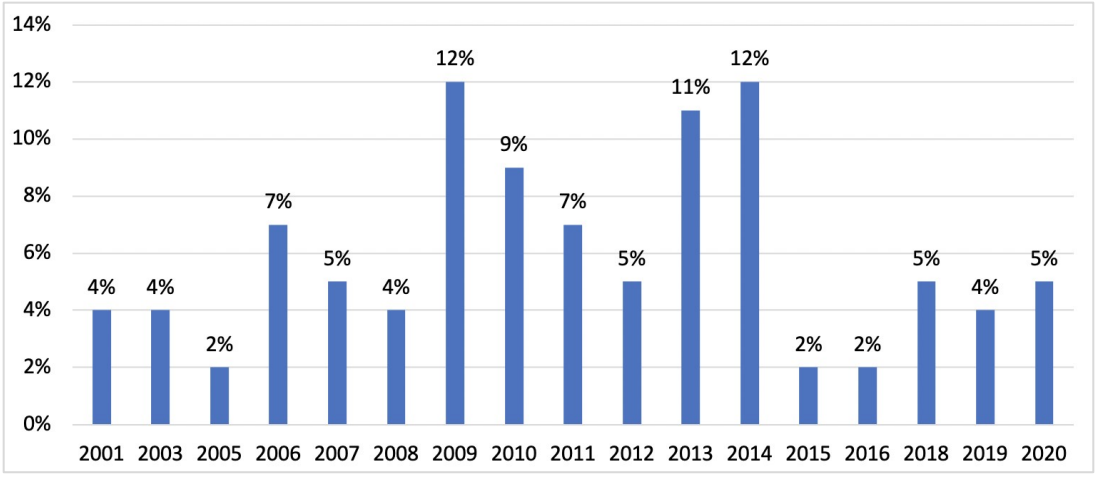


Figure 2.5: Persuasive Games by Years

2.5.3 Persuasive Games by Evaluation Details

According to Figure 2.6, researchers used multiple study methods for persuasive game evaluations. 28 (out of 58) studies used mixed method approach (qualitative and quantitative). For example, Orji et al. [114] used the mixed approach by employing pre-test and post-test surveys (quantitative) to determine the change in healthy eating habits after playing the game followed by semi-structured interviews (qualitative) to record their experiences during the game, challenges they faced, and any other feedback. Similarly, Ferron et al. [55] also employed mixed method approach by using questionnaire (quantitative) for exploring the game aspects experience with larger audience followed by the semi-structured interviews (qualitative) to identify more specific themes.

Further, 12 (out of 58) studies used only quantitative methods. For example, Jacob et al. [84] used only pre-test and post-test surveys for exploring the intrinsic value of educational games. Similarly, Ruggiero [137] also used only surveys as an evaluation tool for measuring change in attitude towards homelessness. Finally, 5 of the studies used only qualitative methods for research. For example, Pollak et al. [131] used just interviews as their evaluation tool for studying healthy eating aspect among the players after playing a mobile-phone based game. We also saw that 16 studies didn't conduct any evaluation or performed analysis.

We also analyzed the success of these studies, see Figure 2.7. 36 out of 58 studies were successful, 8 of them were partially successful, 1 of them were unsuccessful, and 16 of them could not be determined because there was not any study carried out. A game study was described as successful if all of the target outcomes were achieved. However, if none of the target outcomes were achieved, we described it as unsuccessful. A game study was described as partially successful if the game had more than one target outcomes and achieved one or more of the major outcomes but failed to achieve all the major expected outcomes. For example, Gerling et al. [66] successfully demonstrated the use of persuasion for promoting positive attitudes towards people using wheelchairs. On the other hand, Soler et al. [145] demonstrated that the design of their persuasive game can raise awareness for the oral and dental hygiene but may not be effective in changing the players' behaviour in the long run – making their evaluation as partially successful. However, Huss et al. [81] were unsuccessful in identifying any significant changes in asthma symptoms before and after the intervention among participants. Such analysis for the outcomes from each study will not only guide persuasive researchers on selecting the best persuasive strategies for their system but will also guide them to avoid some of the strategies – which are proved to be unsuccessful.

With regards to the analysis of the target audience age group (see Figure 2.8) for the persuasive games, we found that 52% of the games targeted children and teens, followed by 38% for adults and only 3% of the games were developed for elderly people. However, 7% of the games did not report their target population. This is in line with previous research which shows that children's are more responsive to games in general [49].

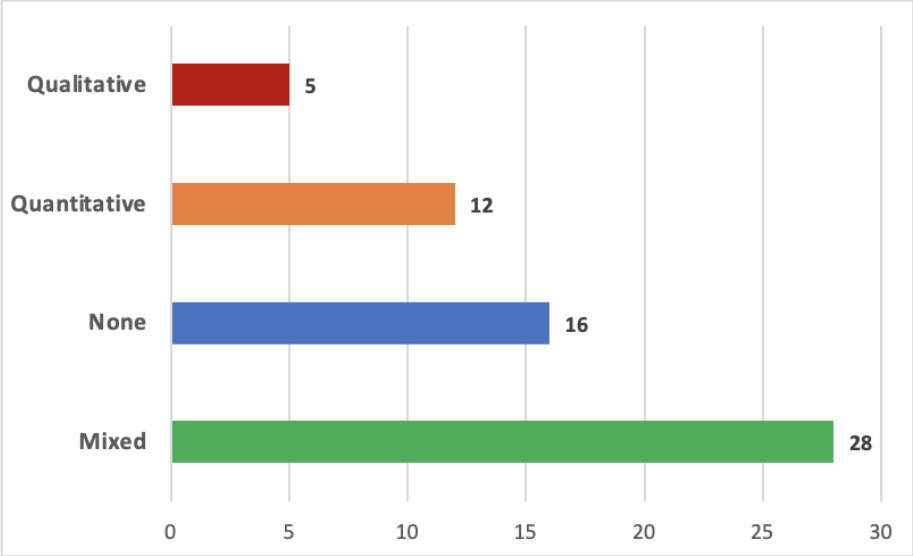


Figure 2.6: Persuasive Games by Study Method

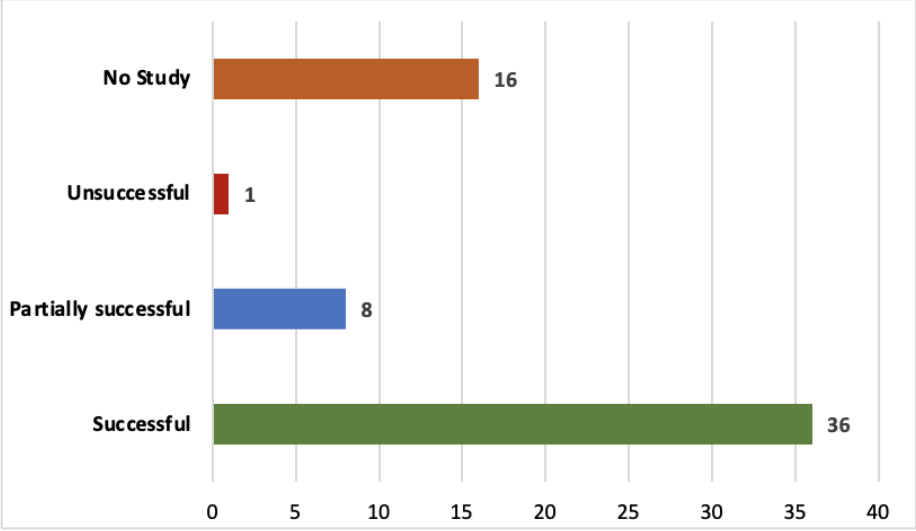


Figure 2.7: Persuasive Game by Success

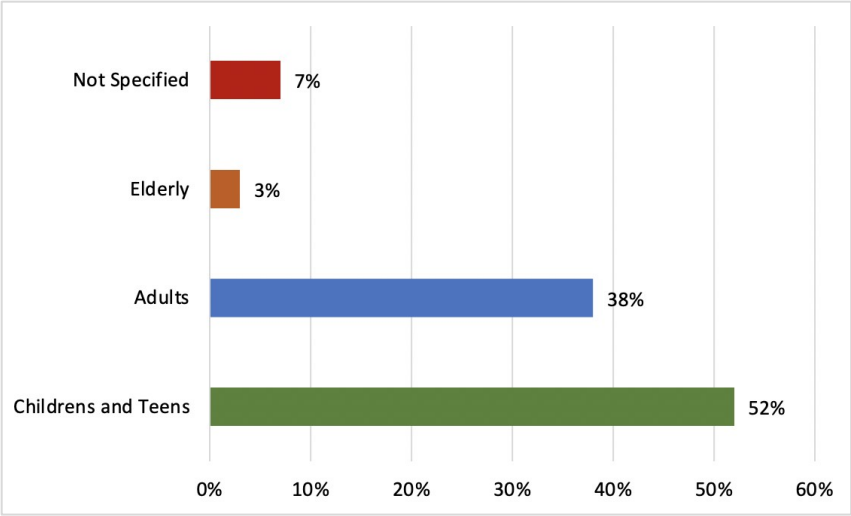


Figure 2.8: Persuasive Games by Age Group

2.6 Behaviour Change Theory

Various behaviour change theories have been applied by the persuasive researchers to determine the motivation and measure the change in behaviour of the individuals. Theory of planned behaviour [4] is one the popular and successful theory employed by previous researchers [105, 113] to measure the motivation as well as change in individuals' desired behaviour. According to theory of planned behaviour, *intention* is the most proximal predictor of behaviour. Moreover, it also states that cognition that affects specific intention are *attitudes* and *self-efficacy*. Attitude is important determinant as it guides the thought and behaviour. Also, self-efficacy is another important determinant as it refers to one's competence or future behaviour. Orji el al. [113] measured change in *attitude, intention,* and *self-efficacy* in their evaluation of a persuasive game to determine the behaviour change among participants towards healthy eating. Similarly, Ndulue [105] also designed and evaluated a persuasive game to measure change in *attitude, intention, self-efficacy,* and *knowledge* of the young Africans towards risky sexual behaviour. Therefore, in our evaluation we are measuring change in attitude, intention, self-efficacy, and knowledge of the participants as a precursor of actual behavior change regarding the adoption of COVID-19 precautionary measures.

2.7 ARCS Motivation Model

The ARCS (Attention, Relevance, Confidence, and Satisfaction) model is a well-known and widely used motivational model [144]. It highlights four qualities that a system needs to have in order to motivate. The ARCS model of motivation implies that there are four main qualities of systems that build and sustain motivation in people: *Attention, Relevance, Confidence,* and *Satisfaction* [92]. It is also a simple and powerful macro theory that combines a wide range of notable motivational theories such as the Self-Efficacy theory, Expectancy-Value theory, Reinforcement theory, Social Learning theory, and Cognitive Evaluation theory [44, 91, 144]. Besides, ARCS motivation model is associated with behaviour and behaviour change [69].

ARCS motivation model is widely used to inform the design and evaluation of the motivational appeal for the persuasive and behaviour change systems in variety of domains, such as persuasive games [43, 160], health [5, 146], and education [38, 138]. Abdessettar applied the ARCS model in developing the persuasive smart mobile school for children [1]. Another group of researchers, Zulkifli et al., employed the ARCS questionnaire to evaluate the motivational appeal of an interactive persuasive system [163]. Other persuasive system designers utilized one or more ARCS motivation model constructs to inform their intervention design. For example, Stockdale et al. employed the Confidence construct of the ARCS motivation model in designing a persuasive intervention aimed at promoting breastfeeding among the first-time mothers by helping them to develop confidence in their ability to breastfeed [146], while [162] employed the Attention construct to increase the motivational appeal of the persuasive elements embedded in their persuasive game. Also, the ARCS motivation model has been used as a scaffolding tool for persuasive and behaviour change systems [41, 42, 44]. Table 2.5 summarizes the four constructs of ARCS motivation model adapted from [112].

Table 2.5: Constructs of ARCS model of motivation [112]

Construct	Definition
Attention	For a system to motivate users, it must arouse and sustain their attention.
Relevance	To motivate users, a system must reflect users' interests and goals. A system that is perceived as helpful and useful in terms of helping users accomplish their goals

Construct	Definition
	is more likely to motivate users. To be relevant, a system must be goal oriented, motive matching, and make use of familiar concepts.
Confidence	People do not like taking on a task with little or no probability of success. Although success is never guaranteed, and people like to be challenged, a challenge that is beyond a user's capability could demotivate them. Users' confidence levels are often correlated with their motivation and the amount of effort put forth towards achieving an objective.
Satisfaction	To motivate users and sustain their motivation, they must derive some satisfaction and reward for their effort.

2.8 Stages of Change in Transtheoretical Model (TTM)

The Transtheoretical Model (TTM) of change [133] is one of the most widely used theories in the health domain for behaviour change [52, 56, 77]. It suggests that an individual progresses through the various stages of behaviour change in order to change an unhealthy behaviour. The main stages of change include: *Precontemplation*, *Contemplation*, *Preparation*, *Action*, and *Maintenance*. Table 2.6 summarizes the five stages of TTM adapted from [123] with the context of COVID precaution behaviour. Many existing behaviour change systems adapt the "one-size-fits-all" approach in which all users are treated alike, and they deliver the same intervention to all the participants irrespective of their stages of change. However, research has stressed that this may not be optimal. As a result, HCI and health researchers have started employing TTM to develop or evaluate behaviour change systems that consider the users' current stage of change in the design of the system [11, 57, 75].

Table 2.6: TTM Stages of Change

Stages of Change	Description

Precontemplation	An individual at this stage is not following any precautionary measures against COVID, such as using hand sanitizers, face masks, hand gloves; and has not considered about starting any of these activities within the next six months.
Contemplation	A contemplator is not following any precautionary measures against COVID but is considering starting these activities in the next six months.
Preparation	A person at the preparation stage has decided to follow precautionary measures against COVID and has taken some steps to achieve his/her goal.
Action	A person at the action stage has started practicing all the precautionary measures against COVID in the last six months.
Maintenance	A person at maintenance stage is following all the precautionary measures against COVID for more than six months.

2.9 Persuasive Strategies for Designing for People at Different Stages of Change

Research has employed the TTM in the design process of persuasive systems in multiple domains like physical activity [11, 56], sustainable energy [75], obesity prevention [95], stress management [52], and substance use [53]. These systems consider the individual's current stage of change and provide them with tailored interventions. For example, Helen et al. [75] suggest that one size does not fit all and applied TTM to energy feedback technology design. Their study tailored the intervention features in the form of textual recommendations to effectively motivate sustainable energy behaviour. For people in earlier stages of TTM (precontemplation, contemplation, and preparation), they used *simulation* as a persuasive strategy to educate them about the pros and cons of the behaviour. On the other hand, for people in the later stages of TTM (Action and Maintenance), they employed *self-monitoring* by allowing the participants to reflect on their performance (of energy-saving actions) and maintain the motivation. Also, another study [56], which applied TTM to support active lifestyle found that people in the early stages of TTM are influenced by intervention strategies that promote education (*suggestion*), increase awareness of

the current behaviour pattern, and offer rewards for following the desired behavior (*reward*). While people in the later stages of TTM are influenced by intervention strategies that present visual feedback (*self-monitoring*) of their current behaviour, and the means to compare that behaviour with others (*comparison and competition*). However, none of these existing work on tailoring persuasive intervention has been targeted at infectious disease domain. Research has suggested that the effectiveness of persuasive intervention may vary across domains [9].

Again, to the best of our knowledge, there is little or no research on tailoring persuasive games specifically to individuals' stages of change by tailoring the persuasive strategies in the domain of infectious diseases. Based on these reviewed works on TTM, we adopt self-monitoring, competition and comparison, reward and suggestion strategies to inform our own design.

2.10 Behaviour Change Interventions for COVID-19 Precautionary Measures

Although researchers are working to study the effects of COVID-19 in various domains, there are very few design interventions are developed to target COVID-19. Previous research [98, 101] shows that promoting the preventive measures will help in prevention of infectious diseases. Recently one of the application was designed to motivate behaviour change in COVID-19 work from home routine by encouraging the users to maintain healthy and active lifestyle [136]. Despite this alarming spread of COVID-19 around the world and wide applications of behaviour change systems and persuasive games in health domains, there is little knowledge on how these persuasive games can motivate people at various stages of change to adopt the COVID-19 precautionary measures. Our research study addresses this gap with the design and evaluation of COVID Pacman: A persuasive game to promote the adoption of COVID-19 precautionary measures tailored to stages of change.

3 CHAPTER 3 COVID PACMAN DESIGN AND IMPLEMENTATION

In this chapter, we shall discuss the process that we followed during the design and implementation of COVID Pacman.

3.1 COVID Pacman Game Design

COVID Pacman is an interactive two-dimensional maze arcade game aimed at promoting the adoption of COVID-19 precautionary measures. To develop an effective persuasive game, we followed the iterative user centered design approach. The game design process was divided into three stages. In each stage, the game was evaluated and refined by persuasive researchers who are experts in the domain of persuasive game design and potential users. The stages are as follows:

Stage 1: Evaluation of the basic game mechanics and narratives

Stage 2: Evaluation of the persuasive strategy's implementation

Stage 3: Evaluation of the user interface (UI) elements

Table 3.1 shows the outcomes of the stages and the following sections explain what we did at each stage.

Table 3.1 – COVID Pacman game design stages and outcomes

STAGES	**OUTCOMES**
Stage 1: Evaluation of the basic game mechanics	Improve functionality of the different game elements.
Stage 2: Evaluation of the persuasive strategy's implementation	Improve the implementation of persuasive strategies.
Stage 3: Evaluation of the user interface (UI) elements	Refine the UI elements of the game.

3.1.1 Step 1: Evaluation of the basic game mechanics and narratives

In stage one, the game was evaluated for the basic game mechanics and narratives. We presented the game narratives and game play to 13 researchers in Persuasive Computing Lab. After the presentation, we elicited the feedback from all the researchers and took note of the changes that will be required. After that, we analyzed every feedback and performed the necessary changes to

the game. The result of the evaluation helped us in improving things like player movements in the game, the functionality of powerups (e.g., hand sanitizer, face masks, hand gloves), and elements in the game such as – appearance of the avatar, functionality of the COVID monsters in the game, and adding game sounds, including game tutorial section.

3.1.2 Step 2: Evaluation of the persuasive strategy's implementation

We improvised on the game from the feedback collected in stage one. In stage two, the game was evaluated for the implementation of the persuasive strategies. In this stage, six persuasive researchers were asked to play the improved version of the game for two days (10 mins per day). After two days, we collected their feedback regarding their thoughts on the implementation of persuasive strategies. The feedback from this stage enabled us to improve the implementation of employed persuasive strategies. For example, we included personal best score for the game points (rewards) and integrated the reliable sources web link from where each suggestion in the game was taken from to increase participants' trust on the suggestions presented in the game.

3.1.3 Step 3: Evaluation of the user interface (UI) elements

We improvised on the game from the feedback collected in stage two. In stage three, the game was finally evaluated for the feedback on user interface (UI) elements. We presented the final version of the game to 13 researchers in the Persuasive Computing Lab. Everyone was asked to provide their feedback in this stage regarding the overall game UI. This helped us refine the positions of some UI elements and colors to make the game more appealing. For example, changing the text color to be more subtle in the game, changing the color and size of the buttons, improving the sound of collecting the powerups in the game.

The final game [37] designed after this iterative design process was the COVID Pacman game used in this study for evaluation.

3.2 COVID Pacman Game Play

COVID Pacman was designed using some of the principles and mechanisms of game-based learning [129]. Principles like learning through fun and enjoyment, and authenticity were employed in the game. Also, mechanisms such as progressively difficult levels, uncertainty and unpredictability were employed in the game. In this section, we describe the multiplication effect

of infection spread in the game; this will be followed by the explanation of the preventive measures that are implemented in the game.

3.2.1 Infection Spread Process in COVID Pacman

The main objective of the game is to create awareness, teach players, and motivate them to keep the COVID-19 precautionary measures such as avoiding getting close to the COVID-19 virus and other humans like avatars who are potentially infected, by making sure the player's avatar maintains social distance from them, while the Pacman goes about carrying the game task of picking coins. To complete a level and progress to the next level, the player has to move around in every corner of the maze to collect coins and the powerups (which are COVID-19 safety and precautionary measures, e.g., hand sanitizer) while maintaining the distance from the virus and other infected humans. This creates an engaging experience as the player has to constantly protect his/her avatar from catching the infection while carrying out the game task of picking coins. Moreover, the movement of the COVID-19 virus in the game is uncertain and unpredictable. This is in line with the uncertainty and unpredictability mechanism of game-based learning [129] and also in line with how COVID-19 infection spreads in the real world.

3.2.2 Preventive Measures Aspect in COVID Pacman

At the start of the game, the player gets a default healthy human-like avatar (see Figure 3.1) representing the player. As the player moves around the maze picking the coins and powerups, they need to continuously observe the precautionary measures including social distancing, wearing face mask, hand sanitizing to protect their avatar against covid-19 infectious which are randomly spreading throughout the game environment. The player has to follow social distancing measures and avoid getting closer to other humans in the game and the virus. If the player comes in contact with the virus, the player's color turns to green showing that he or she is now infected with the virus. In addition to the COVID virus, there are other system-controlled human-like avatars in the game which represent other people in players' community, just as in the real world. The player has to maintain distance from these other people's avatars to avoid being infected or transmitting the infection to others. The player can collect the powerups in the maze (e.g., hand sanitizers, face masks, hand gloves, and tissues) to increase their protective strength. The game is designed with three levels, each equipped with different powerups (different tools for preventive measures against COVID-19) to prevent the player's avatar from catching the infection. To win the game, the player has to complete the three levels, without getting infected and the game difficulty

increases as they progress in level since the number of viruses and humans to avoid increases and uncertainty increases too. The game is designed to be played on desktop and laptop devices (including both Windows and macOS). The game was developed using the Unity game engine [152].

3.3 Deconstructing COVID Pacman

Here we deconstruct the COVID Pacman features and what they each represent.

3.3.1 Game Levels and Sounds

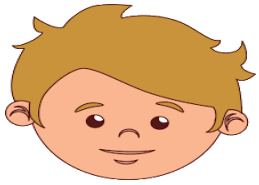
The game promotes the adoption of COVID-19 precautionary measures where the player moves around the maze picking the coins and powerups, they need to continuously observe the precautionary measures and has to maintain distance from the virus as well as other potentially infected individuals in the game. To make the game an engaging experience we divided it into three levels. In each level the player discovers and collects the new powerup to protect themselves from COVID-19 virus in the game and eventually understanding the value of the behavior in their real-life. Different precautions (in line with WHO [158] guidelines) such as Face masks, tissues, hand sanitizers, and hand gloves were included in game levels to promote its frequent use in the game and eventually adapting the same in real life. The game levels get progressively difficult when the player moves from one level to another as the virus spreads to other individuals in the game and the player has to be more cautious now while moving around the maze to avoid themselves from catching the infection. Also, as the player collects the coins and moves around the maze, COVID-19 virus becomes aware of the player position and constantly chases them. This makes the game more challenging and an engaging experience. We also used a jingle as the background soundtrack of the game adapted from [51]. Furthermore, we also used chimes sound for collecting powerups and danger sound when player comes in contact with COVID-19 virus or infected individuals.

3.3.2 Game Characters and Powerups

To resemble to the real-world, COVID Pacman consists of human-like avatar for player and other humans in the game. Also, the monsters from the traditional pacman were improvised to look more like the COVID-19 virus. The game consists of four powerups in total: hand sanitizer, face masks, tissues, and hand gloves. The primary task of the player is to move around the maze using the arrow keys collecting all the coins and powerups while maintaining the physical distance from the

virus and other potential infected individuals. Figure 3.1 below shows the screenshot of player's avatar, other human-like avatar, and powerups used in the game.

Player's Avatar



Other Human-like Avatar

COVID -19 Virus

Face mask

Hand sanitizer

Tissues

Hand gloves

Figure 3.1: Game Characters and Powerups

3.4 Deconstructing Persuasive Strategies in Different Version of COVID Pacman

COVID Pacman was designed in two versions using different persuasive strategies in each. Both of the versions target the same goal of motivating people to adhere to the COVID-19 precautionary measures. We designed two versions to tailor the game based on the individual's stages of change. Version one of the game was designed to motivate people in the early stages of TTM (Precontemplation, Contemplation, and Preparation) according to [11, 56, 75], while version two of the game was designed to maintain the motivation for people in later stages of TTM (action and maintenance) according to [11, 56, 75]. Table 4 shows the summary of persuasive strategy implementation in both versions of COVID Pacman. The strategies were adopted from previous studies that suggested appropriate strategies for people in each stage of change [57, 75].

3.4.1 COVID Pacman Version One

Previous research [11, 75] have shown that people in the earlier stages of TTM (precontemplation, contemplation, and preparation) who are often unaware of the risk associated with non-compliance, ambivalent, or unmotivated require some sort of rewards and education in order to create awareness and motivate them to adopt a healthy behaviour. Based on our related work [57, 95] on persuasive intervention for behaviour change, reward and suggestion strategies can fill this need of educating and motivating the user to adopt a healthy behaviour [57]. As a result of this, we employed rewards and suggestion persuasive strategies in version one of the game. During the gameplay, when a player collects the powerups (hand sanitizer, face masks, hand gloves, tissues), the player is rewarded with extra points and also presented with suggestions on the importance of using that powerup in real life. Figure 3.2 shows the persuasive strategies and other game elements in version one of the game.

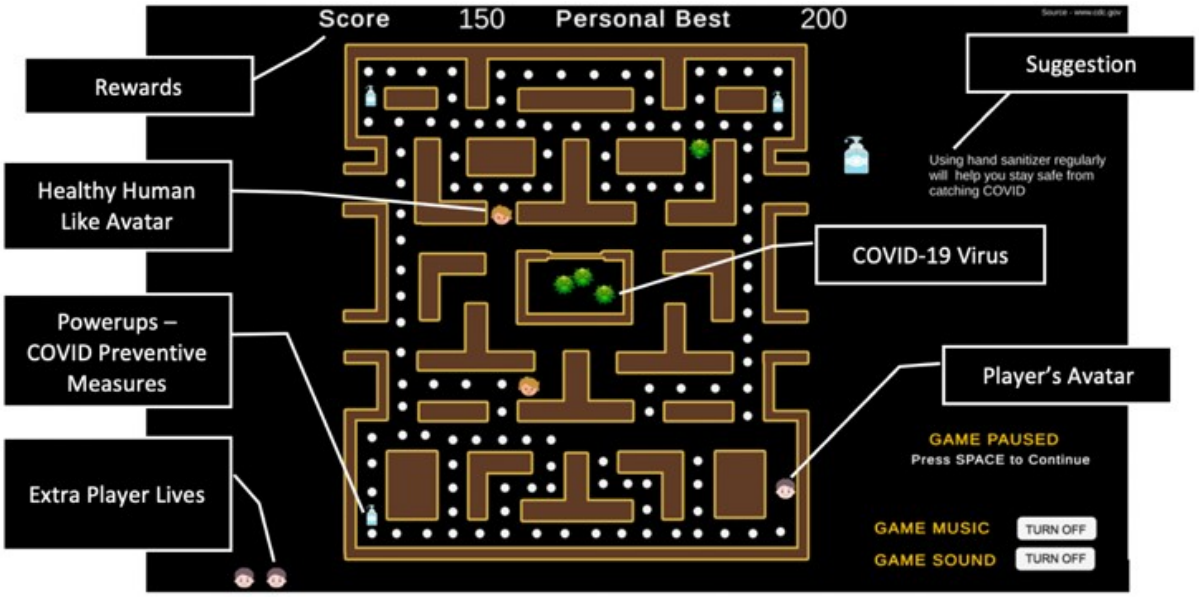


Figure 3.2: COVID Pacman Version One - Rewards and Suggestion based Intervention.

3.4.2 COVID Pacman Version Two

Previous studies [11, 75] have shown that individuals in the later stages of TTM (action and maintenance) who are already putting their behaviour change plan into actions need some external reinforcement and a way to track their progress towards their goals. Hence they are motivated to continue the healthy behaviour by using strategies that allow them to view their progress and some

social influence factors [11, 75]. To accommodate this need we implemented *self-monitoring* and *competition/comparison* persuasive strategies in the version two of the game. In this version, when the player collects the powerups (hand sanitizer, face masks, hand gloves, tissues), the player's health is increased in the health bar by 10%, and when the player gets closer to virus or infected people, the player's health is decreased in the health bar by 10%. In version two, players can see and compare their performance with other players in the games from the leaderboard, along with monitoring their health status from the health bar. Figure 3.3 and 3.4 shows the persuasive strategies and the other game elements in version two of the COVID Pacman.

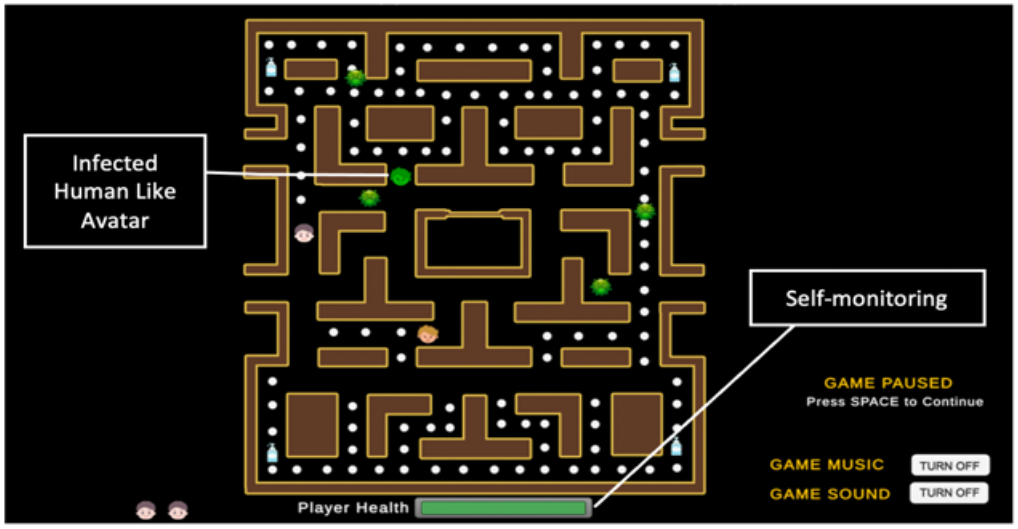


Figure 3.3: COVID Pacman Version Two – Self–monitoring based intervention.

Figure 3.4: COVID Pacman Version Two - Competition and Comparison intervention.

Table 3.2: Summary of Persuasive Strategy Implementation for Both Versions of COVID Pacman

Strategy	**Implementation**
Reward (Version One)	Game points in the form of score.
Suggestion (Version One)	Pop-up suggestions/tips to understand the importance of COVID -19 precautionary measures.
Self-monitoring (Version Two)	Health bar of the player to represent how the infection or powerup is affecting the player's health.
Competition & Comparison (Version Two)	Leaderboard to compare the scores with other players playing the game.

3.5 COVID Pacman Implementation

In this section we highlight the technical flow of the game design and some of the technical actions we took while developing COVID Pacman.

COVID Pacman was developed using the Unity game engine and C# programming language, and photoshop. The reason for choosing the Unity game engine was due to its robustness and compatibility with C#. We also used photoshop for editing assets and exported them as png images. Figure 3.5 below represents the high-level design process of COVID Pacman.

In the implementation of COVID Pacman, the first step we took was to identify the characters, elements and assets we needed in the game. We created and edited majority of our assets in photoshop like game logo, buttons, and icons. We also sourced few open access assets like player avatar, powerups, and COVID virus using the keyword searches on the internet. After editing these assets according to our game requirements, we exported them into png image files. Further, we imported these files into Unity and converted them into sprites while those assets that needed collision were given rigid bodies and polygon colliders.

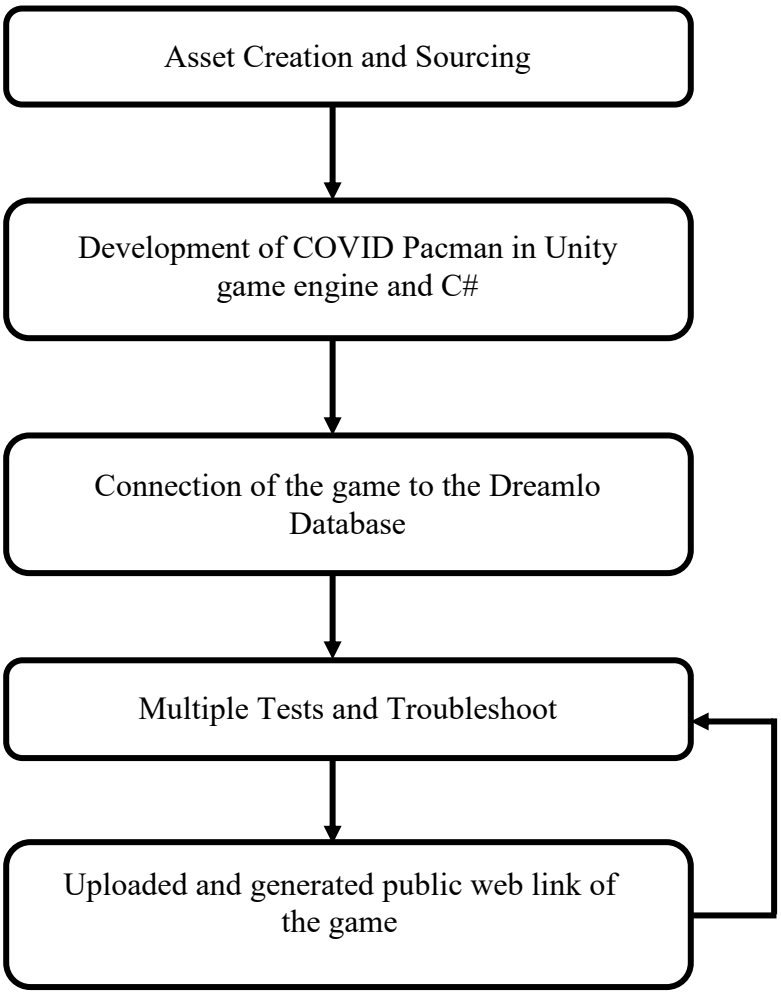


Figure 3.5: High-Level Design Process of COVID Pacman

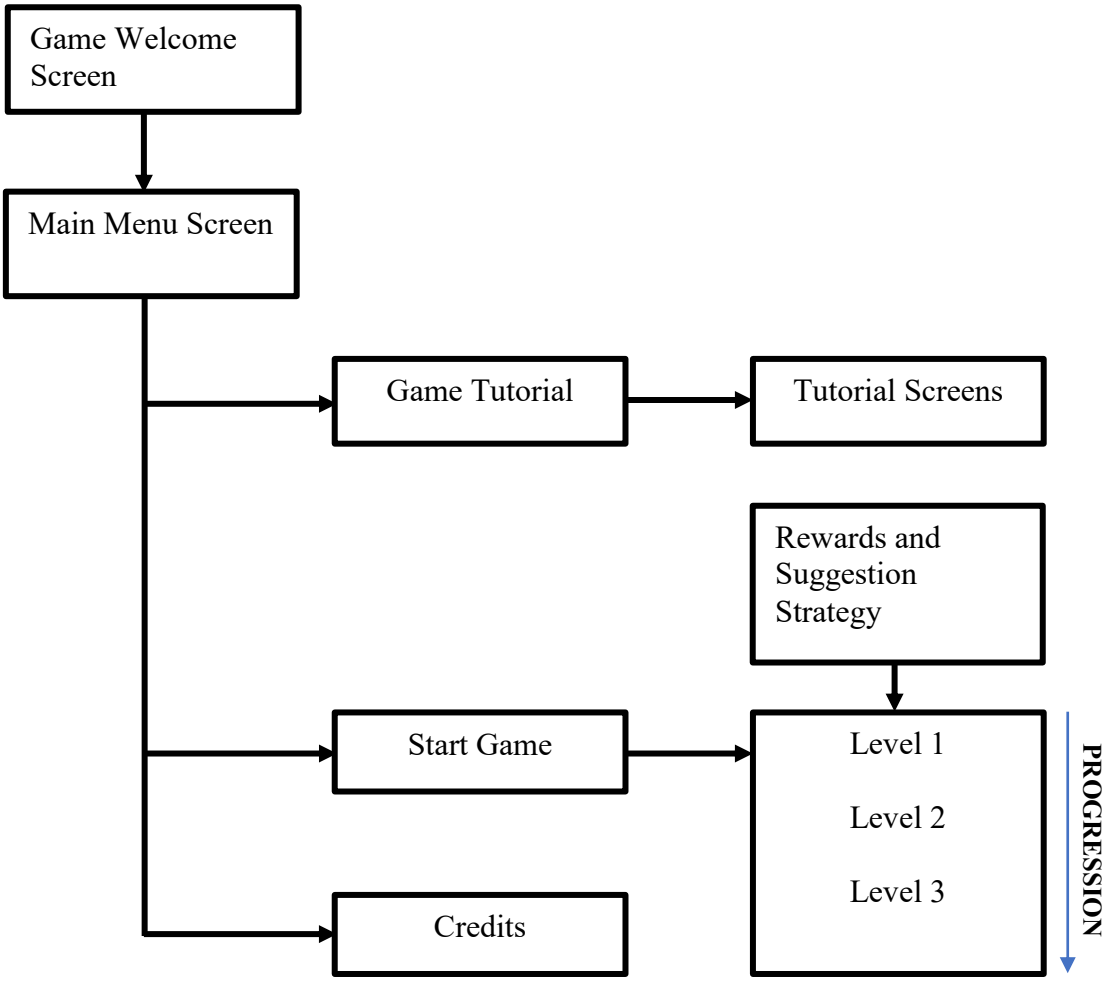


Figure 3.6: High-Level Overview of COVID Pacman Version One Game

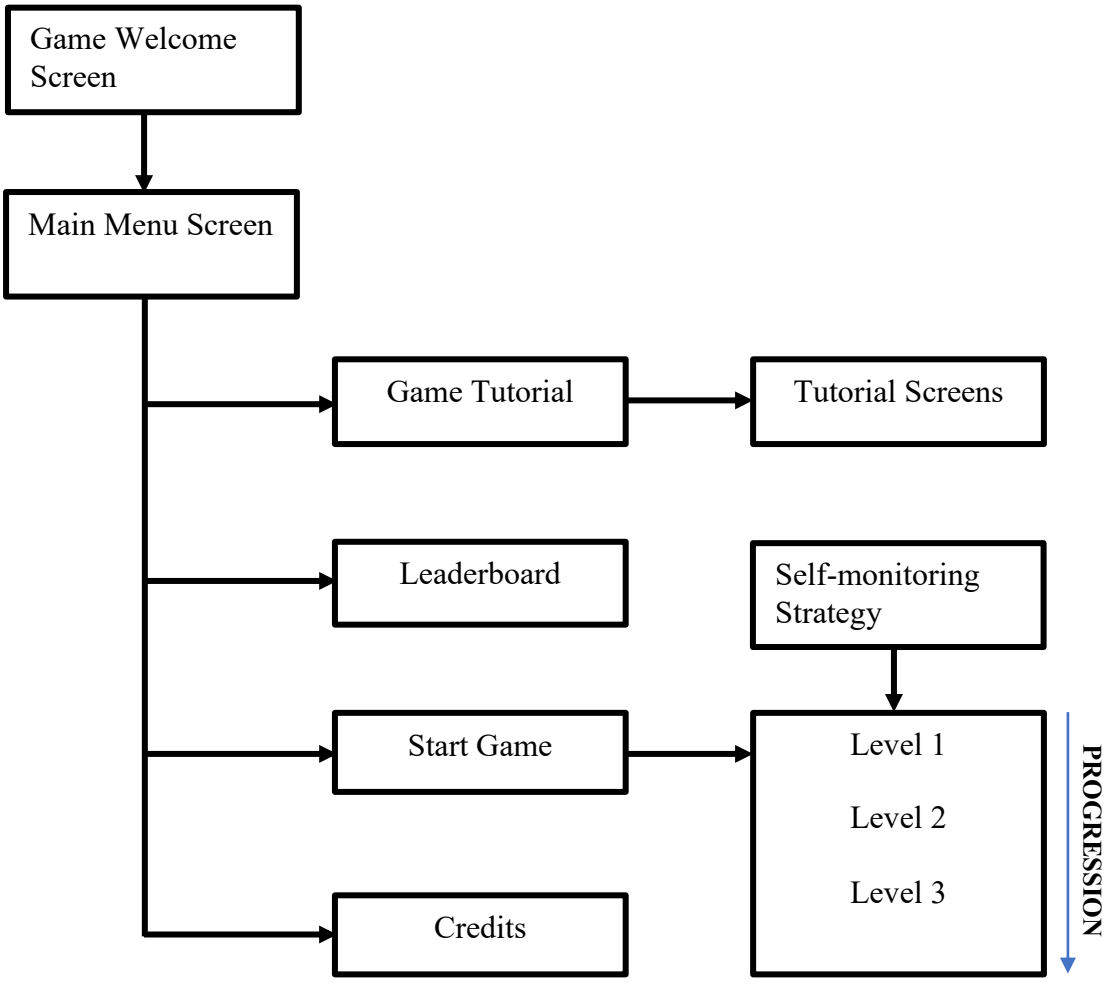


Figure 3.7: High Level Overview of COVID Pacman Version Two Game

In both versions, when the game starts, the player is presented with a prompt to enter a nickname. This nickname is stored in a *playerpref* called username which is also stored in the Dreamlo database for the game. After this, the player can watch the game tutorial from the tutorial slides option present in the game. Tutorial slides are included to help the new user understand the purpose of the game, and to get details about the game elemets and game play of COVID Pacman.

As stated in the deconstructing COVID pacman section, powerups appeared in different levels which player can collect and protect themselves from COVID. Temporary and permanent data in the game such as scores, personal best score, player's health were stored using the player prefabs while the data necessary for our research was stored on the remote server, using a webservice, to our Dreamlo database server.

Figure 3.6 and 3.7 shows an overview of the general flow of the game across the various game scenes for both versions. After developing the game, we used the inbuilt packages to generate the build for Windows and macOS.

4 CHAPTER 4 COVID PACMAN PERSUASIVE GAME EVALUATION

After developing two versions of COVID Pacman, we needed to investigate if it is effective or not, with respect to motivating the desired behaviour change for people at different stages of change. Therefore, we developed the following research questions to guide our evaluation.

The overarching research question for this study is:

Is COVID Pacman effective in promoting the adoption of COVID-19 precautionary measures?

To be able to answer this research questions, we collected the data for individuals at various stages of change relating to their *motivation, attitude, intention, self-efficacy,* and *knowledge* which are precursor to the actual behaviour of adhering to COVID-19 precautionary measures. We collected data from people before playing the COVID Pacman, and their behaviour after playing COVID Pacman, then compared these two variables over the span of time to see if there is a positive or negative change. We had to go through literature to understand the different ways and predictors of behaviour change. To effectively answer this question, we break the question down into smaller question measuring close indicators of behaviour change. The question borders around the factors that determine behaviour change.

According to Ajzen et al. [4] and Orji et al. [122], Attitude, Intention, and Self-efficacy are three main predictors of behaviour change. Moreover, knowledge is also an indicator of behavior change. Research has shown people with more knowledge of the risks and benefits of a target behaviour are more likely to change their behaviour than those without knowledge [28, 46]. Therefore, to determine the effectiveness of COVID Pacman we measured its efficacy with respect to promoting a positive change in Knowledge, Intention, Self-efficacy, and Attitude in adhering to COVID-19 precautionary measures by following research question.

R1: How effective is COVID Pacman with respect to promoting positive changes in attitude, intention, self-efficacy, and knowledge of COVID-19 precautionary measures?

Moreover, ARCS motivation model is widely used to inform the design and evaluation of the motivational appeal for the persuasive and behaviour change systems. Previous studies [1, 163] have employed ARCS to evaluate the motivational appeal of an interactive persuasive system. Therefore, we used ARCS motivation model to determine the overall motivational appeal of

COVID Pacman and across the four dimensions of motivation – Attention, Relevance, Confidence, and Satisfaction – by answering following research question.

R2: How effective is COVID Pacman with respect to motivational appeal?

For people to play the game and keep playing it, it needs to be enjoyable, it has to hold player's interest and also give players a feeling of competence, among many other attributes. This is because, the main reason why people play games in the first place is to have fun, hence we examined whether players had fun while playing the game by exploring the play experience using the following research questions:

R3: How effective is COVID Pacman with respect to promoting positive user experience?

R4: Will tailoring the COVID Pacman to people's stages of change lead to an increased play experience?

Finally, we also examined the perceived persuasiveness of the game with respect to its ability to motivate the desired behaviour change to adopt the COVID-19 precautionary measures, hence the final research question:

R5: How persuasive is COVID Pacman to motivate change in adoption of COVID-19 precautionary measures?

Here is the complete list of research questions we investigate in this thesis.

R1: How effective is COVID Pacman with respect to promoting positive changes in attitude, intention, self-efficacy, and knowledge of COVID-19 precautionary measures?

R2: How effective is COVID Pacman with respect to motivational appeal?

R3: How effective is COVID Pacman with respect to promoting positive user experience?

R4: Will tailoring the COVID Pacman to people's stages of change lead to an increased play experience?

R5: How persuasive is COVID Pacman to motivate change in adoption of COVID-19 precautionary measures?

Table 4.1 shows the research question numbers and their corresponding investigations.

Research Questions	Investigations
R1	Ability of the game to promote positive change in attitude, intention, self-efficacy, and knowledge towards adopting COVID-19 precautionary measures (using pre and post study design)
R2	Effectiveness of CVOID Pacman with respect motivational appeal (using ARCS model of motivation)
R3 and R4	Ability of the game to promote positive play experience (using IMI scales)
R5	Perceived Persuasiveness

4.1 Study Design Overview

To answer these research questions, we conducted a study using online survey to evaluate COVID Pacman followed with a semi-structured interview. The study design is as follows:

To understand the effects of COVID Pacman on participants, we ran a pre-test and post-test study design followed with a semi-structured interview. We gathered participants from advertising the study and had them fill out the pre-test survey (Dec 2020). After that, they we sent them a link to download and play the game for 10 days, for 10 mins per day (Jan 2021). At the end of the 10 days, they were instructed to fill out the post-test survey (Jan 2021). We also tracked the average time spent in the game to ensure participants completed the game. On average, the participants spent 8 mins playing the game per day. After post-test survey we conducted interviews to get deeper insights on participants' experience (Feb 2021). Figure 4.1 shows the flow of the processes in the user study. The following sections presents the details about the study design, data collection, study instruments, and participants' demographics.

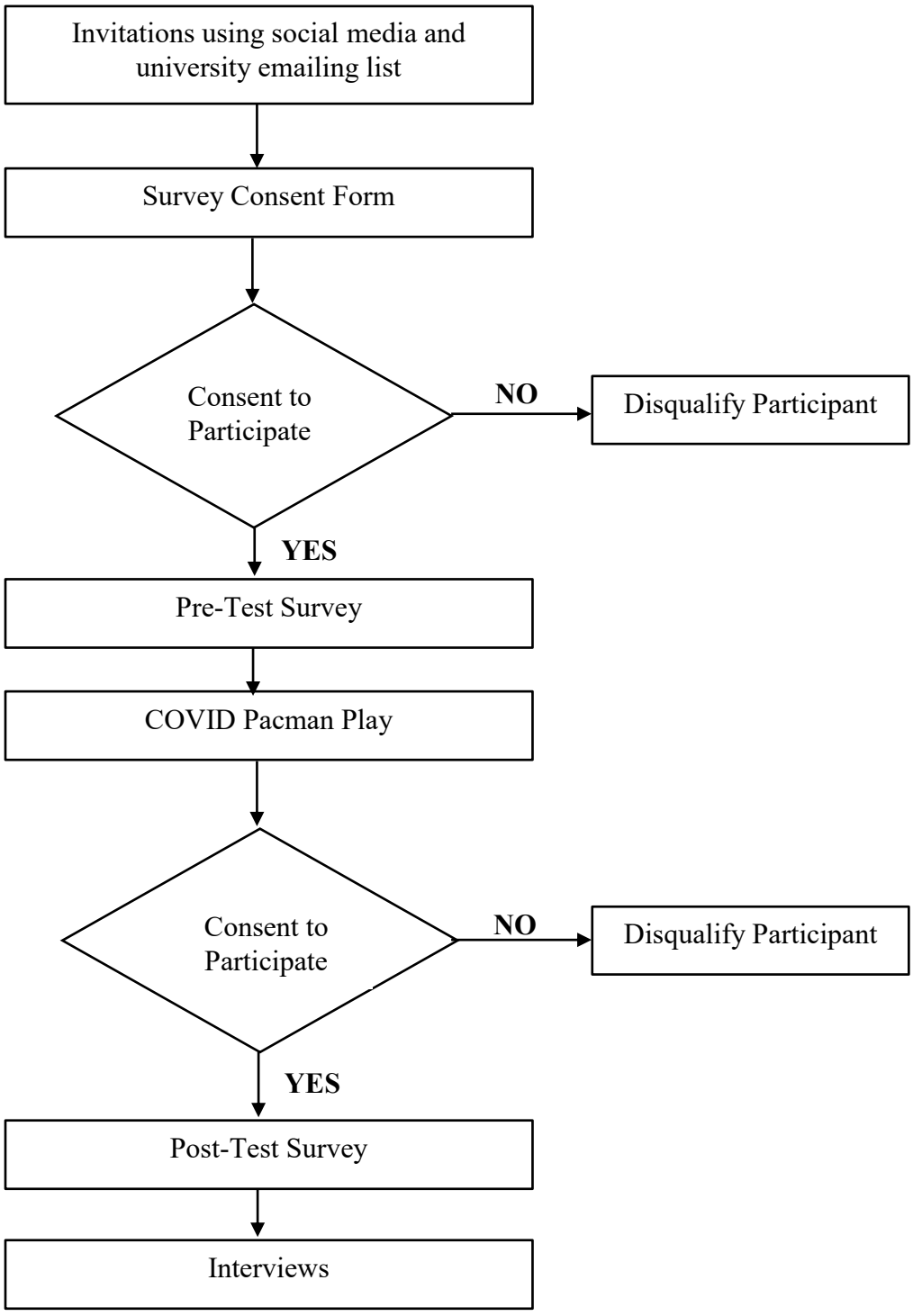


Figure 4.1 Flow of Processes in User Study

4.2 Study Design

To answer the research questions specified above, we designed a study that would collect data about their baseline attitude, intention, self-efficacy, and knowledge (pre-study) about COVID-19 precautionary measures before playing COVID Pacman; have them play the game; then collect the data about their attitude, intention, self-efficacy, knowledge, and motivation after playing the game (post-study). Our survey was designed and hosted on Opinio [111], and all the data collected was stored in the University's online server. Figure 4.2 shows the methodology stages of the research.

Our study was divided into four stages:

First, we conducted a pre-survey to collect the participant demographics, identify their current stage of change, attitude, intention, self-efficacy, and knowledge towards adopting COVID-19 precautionary measures. We used the TTM validated scale adapted from [134] for collecting data to determine each participant's stage of change. We also adapted attitude, intention, and self-efficacy change questions from Orji [113] for our pre-test and post-test surveys for measuring change in attitude, intention, self-efficacy, and knowledge. Also, we developed questions for testing participants knowledge of each precautionary measures used in the game. These questions for COVID-19 information were adopted from reliable sources such as WHO [158], and avert.org [13].

Secondly, using the data (i), we determined each player's stage of change according to TTM. Next, we divided the participants into two groups – people in early stage TTM – precontemplation, contemplation, and preparation (n=59), and people in later stage TTM – action and maintenance (n=68). To eliminate the possibility of any bias, we randomly assigned people from each stage to play either tailored version or non-tailored version of the game. So, in all, we have four experimental groups – Early stage tailored version, Later stage tailored version, Early stage non-tailored version, and Later stage non-tailored version.

Thirdly, we conducted a post-survey, after playing the game, to identify change in participants' attitude, intention, self-efficacy, and knowledge towards adopting COVID-19 precautionary measures (for answering R1). We used the same scales and questions as used in the pre-test survey. Moreover, we included questions measuring attention, relevance, confidence, and satisfaction for measuring ARCS constructs adapted from [112] (for answering R2). Additionally, we adapted questions from [113] for measuring play experience – enjoyment, invested effort, usefulness,

perceived competence, and tension to examine player's experience (for answering R3 and R4). Finally, we measured the persuasiveness of the overall game (for answering R5).

Finally, to collect the qualitative data, we conducted one-to-one interviews online with 18 participants (Early stage tailored: n=5, Later stage tailored: n=5, Early stage non-tailored: n=4, Later stage non-tailored: n=4) who played the game and completed the pre and post survey. Each interview lasted for about 20 mins. We audio-recorded all of the 18 interviews with the participant's permission. This semi-structured interview helped us to collect rich qualitative feedback from the participants about their experience with the game, its impact on their behaviour with respect to promoting adherence to COVID-19 precautionary measures, what they like/dislike about the game, their thoughts on the persuasive features used in the game, and any suggestions for improvements in the game.

People in Early stage tailored version played the tailored versions of the game which was designed for them using strategies that were identified as suitable for them from previous research, reward and suggestion strategy [56, 75] (version one). Those in the Later stage tailored version also played a version of the game designed for them using strategies that were identified as suitable for them based on previous research, self-monitoring and competition/comparison strategy [56, 75] (version two). However, people in Early stage non-tailored version and Later stage non-tailored version played version two and version one respectively, which was not tailored according to their current stage of change.

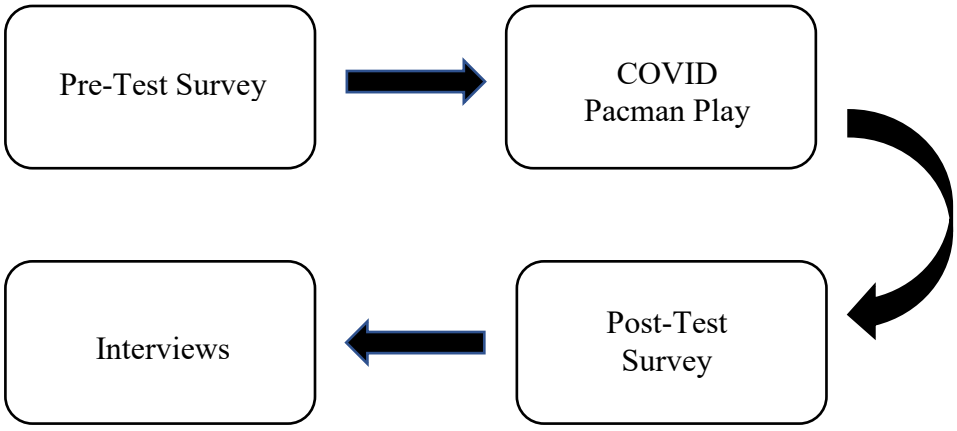


Figure 4.2: Study Methodology Stages

4.3 Data Collection

We conducted an online survey involving participants recruited from advertising to the public using various channels such as social media and university's emailing list. We also used word of mouth and snowball sampling techniques that allowed participants to recruit more people.

For our pre-survey hosted on Opinio [111], there were five sections. The first section contains the demographic-related questions such as participants' age group, gender, marital status, educations qualifications, and primary area of study or experience. In the second section, we asked participants about their gaming background, such as how often they play the games and their most preferred platform where they play games. The third section of the survey includes a question to identify the participants' current stage of change. Fourth section of the survey includes 32 questions related to attitude, intention, and self-efficacy adapted from [113]. Final section of the survey includes 8 questions for testing participants' knowledge on COVID adapted from reliable sources.

The post-survey of our study consisted of the questions measuring change in attitude, intention, self-efficacy, and knowledge which are same as used in pre-survey. Further, post-survey also included questions measuring attention, relevance, confidence, and satisfaction consisting of 12 items measured on a 7-point Likert scale (ranging from "1 – Strongly Disagree" and "7 – Strongly Agree"). The validated scales and questions for measuring ARCS constructs were adapted from [112]. In addition to that, post-survey also measures the play experience – enjoyment, invested effort, usefulness, perceived competence, and tension using 24 items on a 7-point Likert scale of Intrinsic Motivation Scale [164] adapted from [164] to examine player's experience. Finally, the last section in the post-survey measures the persuasiveness of the overall game with 5 items adapted from [148]. Our survey responses were measured on a 7-point Likert scale (ranging from "1 – Strongly Disagree" and "7 – Strongly Agree").

4.4 Study Instruments

Below is the list of instruments used in this study:

- Pre-test online survey form
- COVID Pacman game
- Post-test online survey form

- Semi-structured interview
- Dreamlo Server [48] for gameplay data
- Dal Opinio Server
- SPSS and MS Excel

4.5 Participants' Demographics

For our pre-survey we collected 138 participants from advertising and sending emails to potential participants. Out of these 138 participants, 127 of them played the game and filled the post-survey. After excluding the data of 11 participants who dropped out of the study, we included 127 responses in our final analysis.

For the included participants, we had 57% males and 43% females (Figure 4.3). By marital status 76% were single while 24% were married (Figure 4.4).

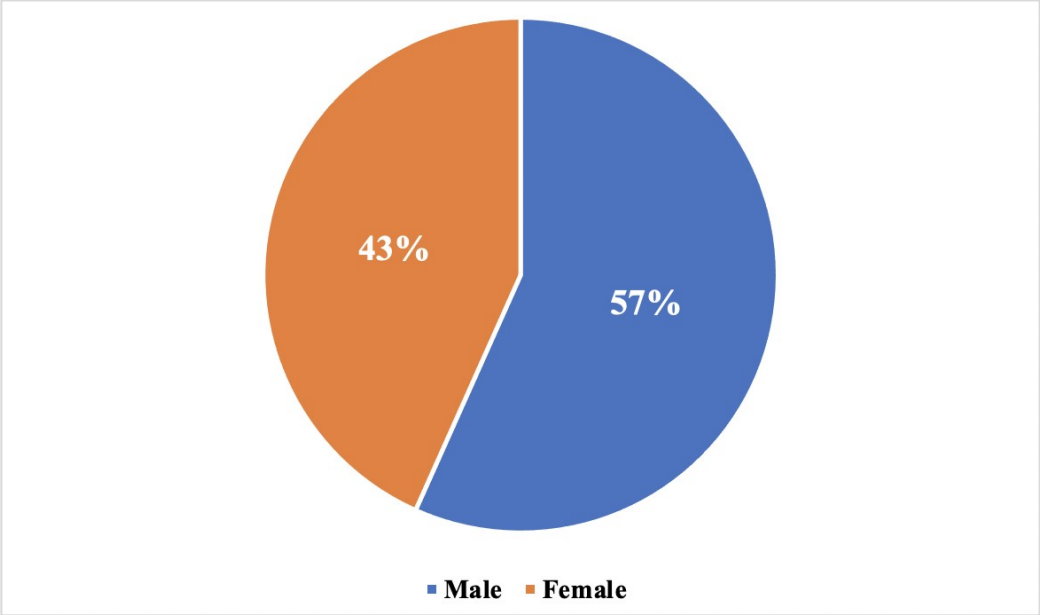


Figure 4.3: Demographics by Gender

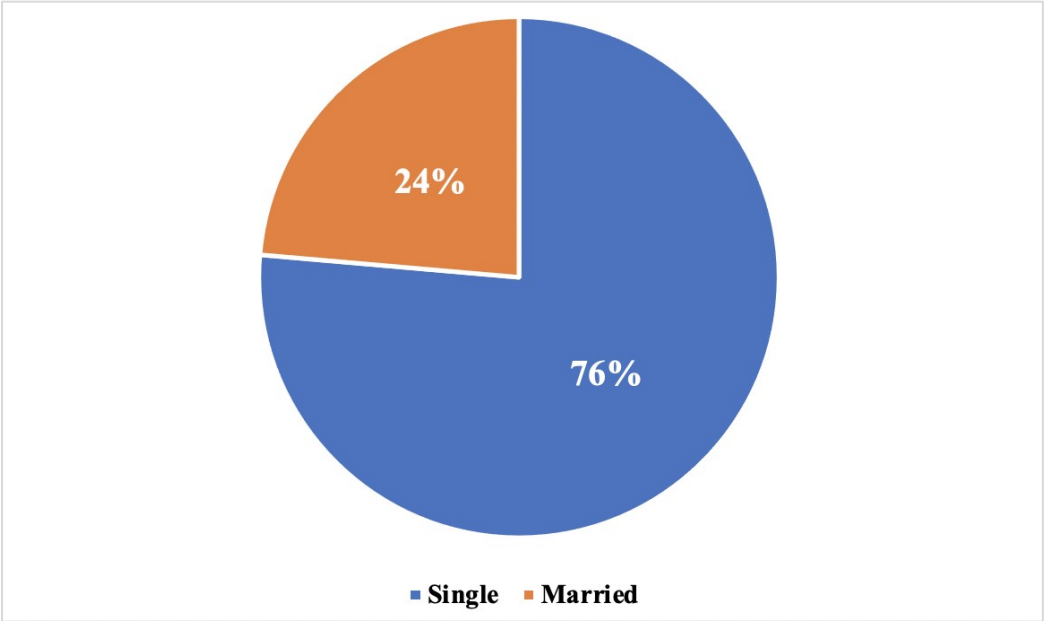


Figure 4.4: Demographics by Marital Status

The largest age group in our sample was ‘18-25’ with 55%, followed by ’26-35’ with 27%. The smallest age group we had was ’46 and Above’ with 8% followed by ’36-45’ with 10% (Figure 4.5).

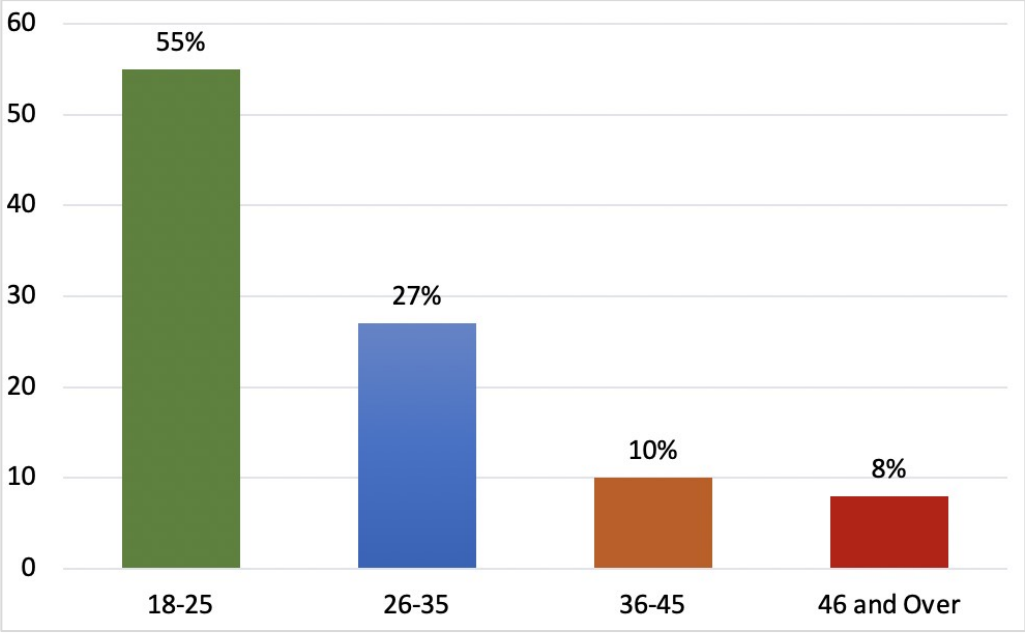


Figure 4.5: Demographics by Age

With respect to the educational level, bachelor's degree are most represented with 57%, followed by master's degree with 19%, high school or equivalent with 17%, college diploma and doctoral degree had the lowest with 6% and 1% respectively as shown in Figure 4.6.

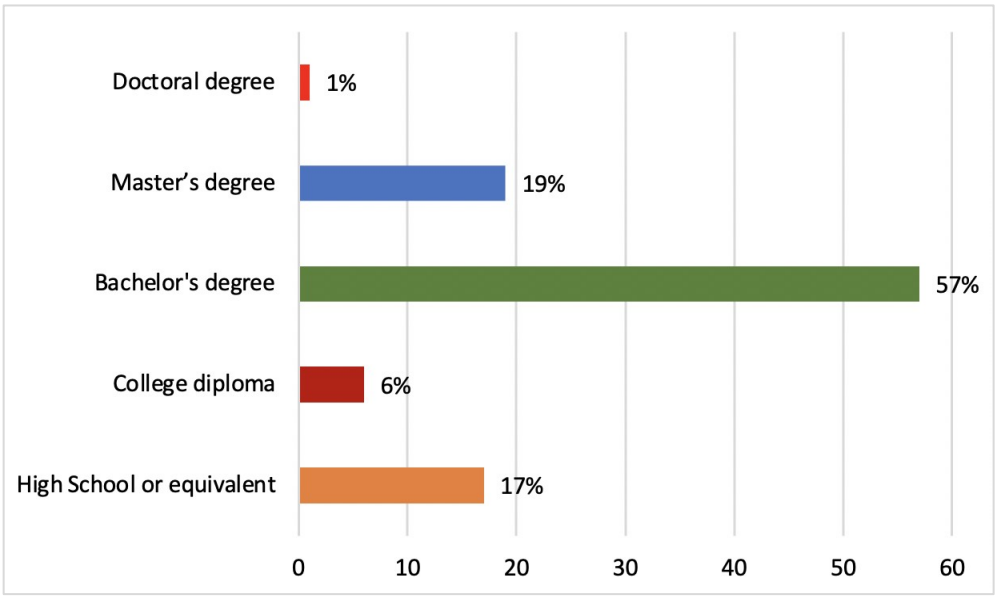


Figure 4.6: Demographics by their highest level of education

36% of the participants play games every day, while 25% of them play games many times a day. 20% participants played many times a week, 13% played games once or twice a week, 4% played once or twice a month, while 2% played games once or twice a year as seen in Figure 4.7. We deduce from this that our population leaned towards gamers since 61% of the participants played the game at least once every day and 20% played multiple times per week.

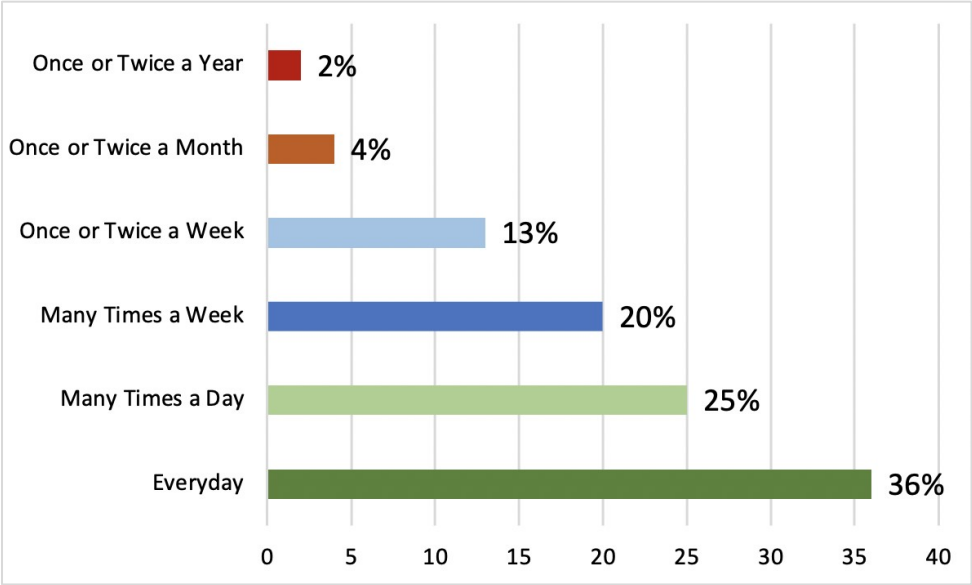


Figure 4.7: Demographics by Gameplay Frequency

Desktop and Mobile with 45% for both came out as the devices used by most participants in playing games (see Figure 4.8). This is probably why the game designers target desktop and mobile platforms for their games as these are the two devices that are more commonly used by the people to play the games.

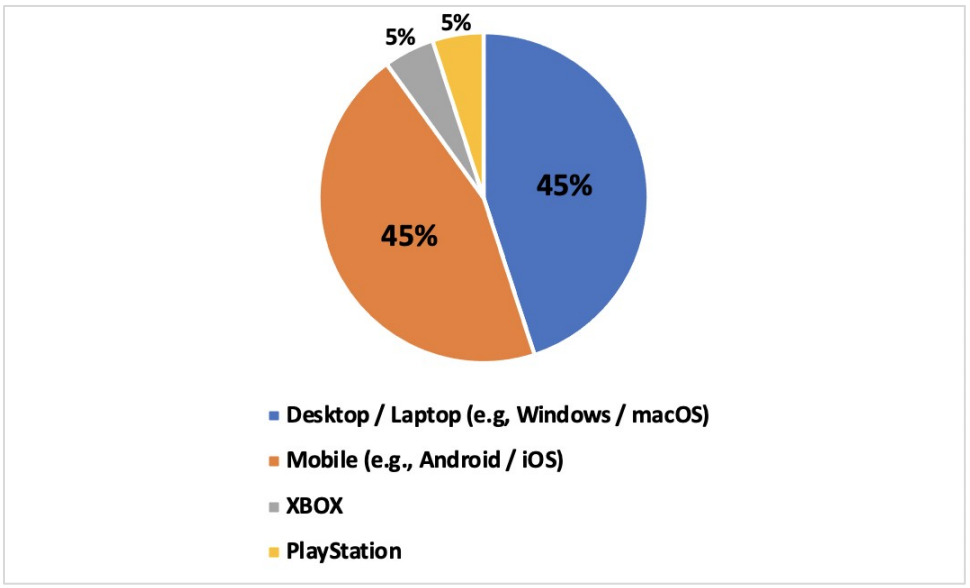


Figure 4.8: Demographics by Device used the most in playing games

Table 4.2: Summary of Participants' Demography

Total Participants = 127	
Gender	Male (57%), Female (43%)
Age	18-25 (55%), 26-35 (27%), 36-45 (10%), 46 and Over (8%)
Marital Status	Single (76%), Married (24%)
Education	High school or equivalent (17%), College diploma (6%), Bachelor's degree (57%), Master's degree (19%), Doctoral degree (1%)
Stages of Change	Precontemplation (7%), Contemplation (16%), Preparation (24%), Action (35%), Maintenance (18%)
Gameplay Frequency	Everyday (36%), Many times a day (25%), Many times a week (20%), Once or twice a week (13%), Once or twice a month (4%), Once or twice a year (2%)
Main Device used for Gameplay	Desktop (45%), Mobile (45%), Xbox (5%), PlayStation (5%)

4.6 Data Analysis

To analyze the quantitative data and answer our research questions, we used well-known analytics methods via IBM's SPSS. To answer our R1, we first conducted a paired-sample t-test of the overall participants responses (n=127). After that, we ran RM-ANOVA with time (pre-test, post-test) as within subject factors and stages of change (Early stage, Later stage) and Intervention Type (Version One, Version Two) as between subject factors on attitude, intention, self-efficacy, and knowledge towards adopting COVID-19 precautionary measures. To answer our R2, we ran one-sample t-test on ARCS constructs to measure the motivational appeal of the game overall as well as across four dimensions of motivation (attention, relevance, confidence, satisfaction), followed by One Way ANOVA to compare the motivational appeal for people at different stages of change. To answer our R3 and R4, we ran one-sample t-test for each of the variables under player experience, followed by two-way (multivariate) ANOVA with stages of change (early stage and later stage) and intervention type (version one and version two) as between-subject factors and play experience (interest-enjoyment, perceived competence, effort-importance, pressure-tension,

value-usefulness) as dependent measures. Finally, to answer our R5, we ran one-sample t-test to evaluate the perceived persuasiveness of COVID Pacman.

To analyze the qualitative data, first we transcribed all the interviews. Firtst, we analyzed the interview comments by classifying responses into four experimental groups (early stage tailored, later stage tailored, early stage non-tailored, later stage non-tailored) to investigate the results of tailoring the game based on individual's stages of change. After that, we performed thematic analysis separately on overall survey comments and our interview transcription. While performing thematic analysis, we reviewed each comment by clustering similar comments together to form a theme in iterative manner.

5 CHAPTER 5 STUDY RESULTS

In this chapter, we present the results from both quantitative and qualitative evaluation of COVID Pacman. Specifically, in the following subsections, we present the findings on overall change in behaviour after playing COVID Pacman (with respect to attitude change, intention change, self-efficacy change, and knowledge change as adapted from Orji [113]) and the change in behaviour across the experimental groups (Early stage tailored version, Later stage tailored version, Early stage non-tailored version, and Later stage non-tailored version). Next, we present the results of comparing the effectiveness of tailored and non-tailored versions across the group. Further, we present the motivational appeal of COVD Pacman overall as well as across four dimensions of motivation (attention, relevance, confidence, satisfaction). We also present, the results of play experience of COVID Pacman as measured using the IMI subscales [164] of interest and enjoyment, perceived competence, effort and importance, value and usefulness, and pressure and tension. Moreover, we also present the results of overall perceived persuasiveness of COVID Pacman. Finally, we discuss the qualitative results of the interviews as well as comments collected from participants in online survey. The reliability analysis showed that all the scales demonstrated internal consistency, with Cronbach's alpha values above the recommended threshold of 0.70.

5.1 Overall Efficacy of COVID Pacman in Promoting Behaviour Change

To investigate this, we performed a paired-sample t-test on the combined data to determine if the mean of pre attitude, intention, self-efficacy, and knowledge (before playing the game) differ significantly from the mean of post attitude, intention, self-efficacy, and knowledge (after playing the game). The result is as follows: attitude ($t(126) = -12.26$, $p < 0.0005$), intention ($t(126) = -12.62$, $p < 0.0005$), self-efficacy ($t(126) = -13.50$, $p < 0.0005$), and knowledge ($t(126) = -11.05$, $p < 0.0005$).

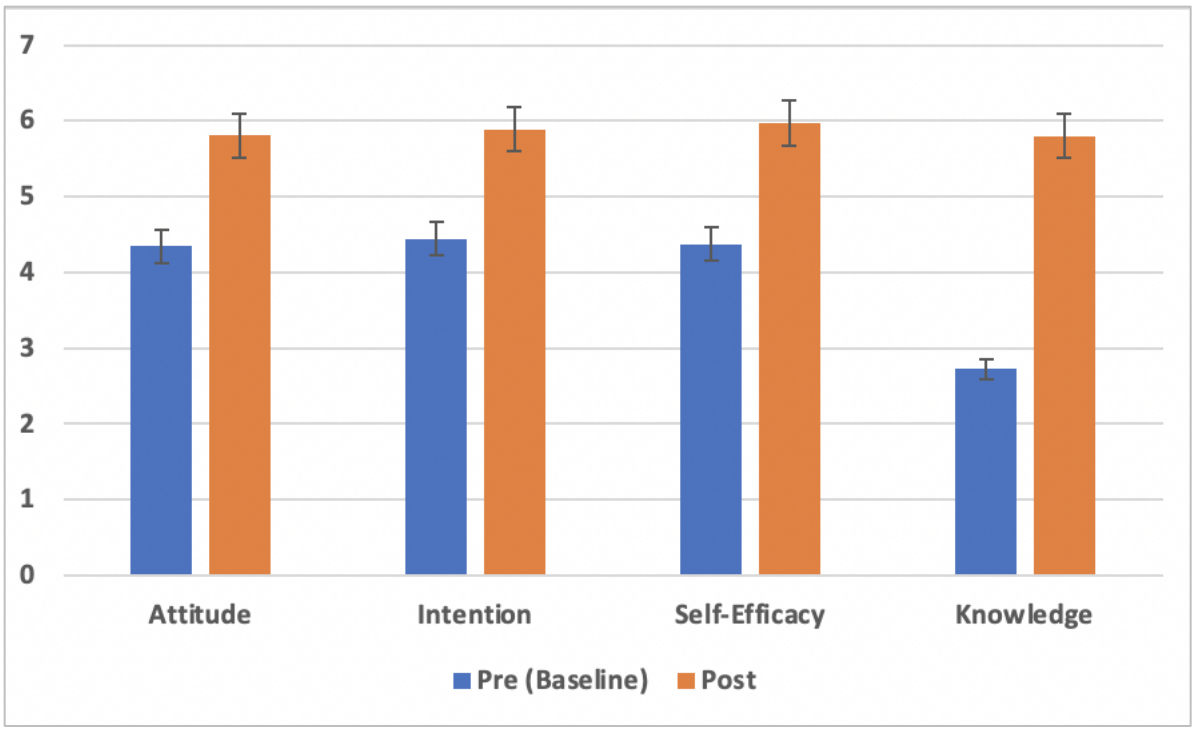


Figure 5.1: A bar chart showing the paired sample statistics for overall pre-test and post-test means for attitude, intention and self-efficacy, and knowledge. Error bars represent a 95% confidence interval.

Table 5.1: Paired sample t-test for Attitude, Intention, Self-efficacy, and Knowledge change

Pair	**M**	**SD**	**t_2**	**p**
Pre-Attitude – Post-Attitude	-1.47	1.35	-12.26	.000
Pre-Intention – Post-Intention	-1.44	1.29	-12.62	.000
Pre-Self Efficacy – Post-Self Efficacy	-1.60	1.33	-13.50	.000
Pre-Knowledge – Post-knowledge	-3.07	3.13	-11.05	.000

From the results above in Table 5.1 and Figure 5.1, we can conclude that COVID Pacman overall led to statistically significant increase in the attitude, intention, self-efficacy, and knowledge of participants with respect to adoption of COVID-19 precautionary measures.

We can therefore conclude that overall COVID Pacman motivated a **positive change in attitude, intention, self-efficacy, and knowledge** of the participants towards adopting COVID-19 precautionary measures.

5.2 Effects of COVID Pacman for Various Groups

We investigated for possible differences in players' attitude, intention, self-efficacy, and knowledge of COVID-19 precautionary measures with respect to individuals' stages of change, intervention type, and time.

After validating the data for the assumptions of ANOVA, we conducted a Repeated Measures Analysis of Variance (RM-ANOVA) with time (pre-play, post-play) as a within-subjects factor and stages of change (Early stage, Later stage) and Intervention Type (Version One, Version Two) as between-subjects factors on attitude, intention, knowledge, and self-efficacy toward adopting the COVID-19 precautionary measures.

5.2.1 Stages of Change (Early Stage and Later Stage)

The results of the RM-ANOVA show significant difference between individuals at different stages of change – early stage and later stages – overall on all measure. Individuals' stages of change have significant effect on overall ratings of attitude ($F_{123} = 549.881$, $p < 0.0005$, $\eta^2 = 0.817$), intention ($F_{123} = 440.053$, $p < 0.0005$, $\eta^2 = 0.782$), self-efficacy ($F_{123} = 492.662$, $p < 0.0005$, $\eta^2 = 0.800$), and knowledge ($F_{123} = 4.103$, $p < 0.05$, $\eta^2 = 0.032$). This means that the individuals at the early stage and later stage rated their attitude, intention, self-efficacy, and knowledge differently overall, establishing that there were group-level differences in the ratings. Overall, the posthoc pairwise comparison shows that the people in the later stage group show higher positive change in attitude ($p < 0.0005$), intention ($p < 0.0005$), self-efficacy ($p < 0.0005$), and knowledge ($p < 0.05$). This shows that overall COVID Pacman is more effective for people in later stage of behaviour change.

5.2.2 Intervention Type (Version One and Version Two)

The results show significant differences between the interventions – Version One and Version Two – on attitude, intention, and self-efficacy. Intervention type has significant main effect on overall ratings of attitude ($F_{123} = 23.018$, $p < 0.0005$, $\eta^2 = 0.158$), intention ($F_{123} = 41.459$, $p < 0.0005$, $\eta^2 = 0.252$), and self-efficacy ($F_{123} = 25.934$, $p < 0.0005$, $\eta^2 = 0.174$). However, there were no significant differences between the interventions with regards to knowledge change.

Intervention type has no significant main effect on overall knowledge ($F_{123} = 2.774$, $p = 0.098$, $\eta^2 = 0.022$). Overall, the posthoc pairwise comparison shows that the people who played Version One experienced the higher positive change in attitude ($p < 0.0005$), intention ($p < 0.0005$), and self-efficacy ($p < 0.0005$). This shows that overall, without considering the stages of change – Version One of the game was more effective in promoting behaviour change.

5.2.3 Time (Pre-test and Post-test)

The result show significant main effect of time on attitude ($F_{123} = 761.660$, $p < 0.0005$, $\eta^2 = 0.861$), intention ($F_{123} = 569.966$, $p < 0.0005$, $\eta^2 = 0.823$), self-efficacy ($F_{123} = 835.385$, $p < 0.0005$, $\eta^2 = 0.872$), and knowledge ($F_{123} = 429.989$, $p < 0.0005$, $\eta^2 = 0.778$) overall. This means that there is a significant difference between the pre and post-tests when individual's stages of change and intervention type are considered together – that is without separating the participants into various groups. Attitude, intention, self-efficacy, and knowledge measured immediately following the gameplay were significantly improved from that taken before the gameplay as shown in Figure 5.2. This means that after playing the COVID Pacman participants reported an increased attitude ($p < 0.0005$), self-efficacy ($p < 0.0005$), knowledge ($p < 0.0005$), and intention ($p < 0.0005$), towards adopting COVID-19 precautionary measures as shown by post-hoc pairwise comparison test. The game was therefore successful in promoting a positive attitude, self-efficacy, intention, and knowledge over all groups (early stage and later stage) and intervention types.

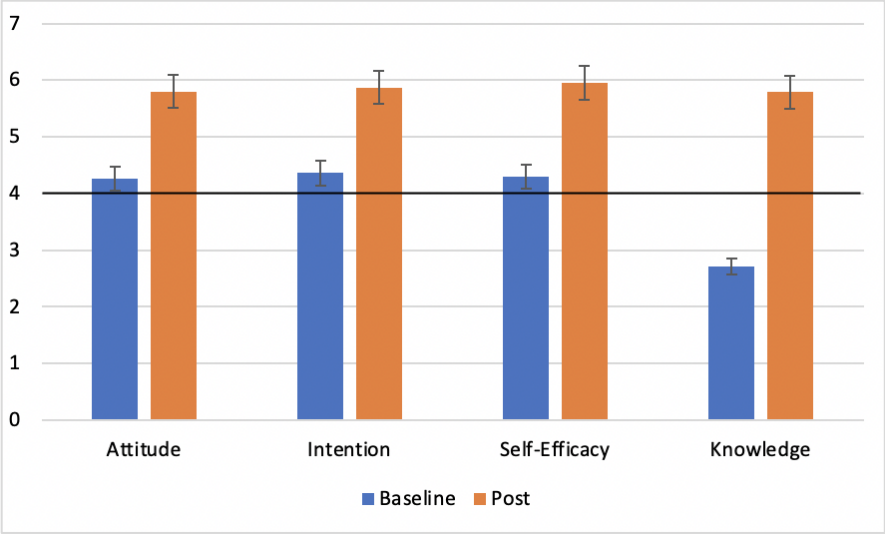


Figure 5.2: A bar graph showing the paired means of attitude, self-efficacy, intention, and knowledge ratings over time – baseline and post. Error bars represent a 95% confidence interval.

5.2.4 Interactions between Individual's Stages of Change and Time

The result shows significant interactions between stages of change and time for three measures – attitude (F_{123} = 213.474, $p < 0.0005$, η^2 = 0.634), intention (F_{123} = 111.244, $p < 0.0005$, η^2 = 0.475), and self-efficacy (F_{123} = 154.323, $p < 0.0005$, η^2 = 0.556). However, there was no significant interaction between stages of change and time for knowledge (F_{123} = 0.233, p = 0.630, η^2 = 0.002). Pairwise comparisons show that playing COVID Pacman promoted positive change in all measures for people in tailored groups as compared to non-tailored groups. All the differences were significant at $p < 0.05$. These results are further explained in the 3-way interaction between stages of change, intervention type, and time.

5.2.5 Interactions between Intervention Type and Time

Considering the efficacy of COVID Pacman for promoting the positive change in all the measures overall, I next investigated the differences between the two versions of COVID Pacman with respect to their ability to influence change in attitude, intention, self-efficacy, and knowledge overtime – pre and post-test. The result showed significant interaction between intervention type and time for all the measures – attitude (F_{123} = 23.055, $p < 0.0005$, η^2 = 0.158), intention (F_{123} = 29.162, $p < 0.0005$, η^2 = 0.192), self-efficacy (F_{123} = 41.591, $p < 0.0005$, η^2 = 0.253), and knowledge (F_{123} = 3.748, $p < 0.05$, η^2 = 0.030). This shows that there is significant difference in the effectiveness of both versions overall. Pairwise comparisons show that people playing Version One (Rewards and Suggestion) of COVID Pacman experienced higher positive change in attitude ($p < 0.0005$), intention ($p < 0.0005$), self-efficacy ($p < 0.0005$), and knowledge ($p < 0.0005$). This shows that version one of the game that designed using the rewards and suggestion strategies was more effective in promoting the behaviour change over the time (pre and post) than the version two designed using the self-monitoring and competition/comparison strategies.

5.2.6 3-way Interaction between Stages of change, Intervention Type, and Time

The significant 3-way interaction shows the beneficial results of tailoring the persuasive game according to individual's stages of change. The results shows that there are significant interactions between the stages of change, intervention type, and time for all measures – attitude (F_{123} = 263.695, $p < 0.0005$, η^2 = 0.682), intention (F_{123} = 178.988, $p < 0.0005$, η^2 = 0.593), self-efficacy

($F_{123} = 251.842$, $p < 0.0005$, $\eta^2 = 0.672$), and knowledge ($F_{123} = 323.263$, $p < 0.0005$, $\eta^2 = 0.724$). Pairwise comparison show that for:

Early Stage: Our results show that tailored version of the game (rewards and suggestion version) was more effective for all measures for people in early stage. Specifically, playing tailored version of the game motivated an increase in attitude ($p < 0.0005$), intention ($p < 0.0005$), self-efficacy ($p < 0.0005$), and knowledge ($p < 0.0005$) towards adopting COVID-19 precautionary measures while playing non-tailored version (self-monitoring and competition/comparison version) led to no significant change in either attitude ($p = 0.673$), intention ($p = 0.428$), self-efficacy ($p = 0.417$), and knowledge ($p = 0.692$) for people in early stage.

Later Stage: Our results show that tailored version of the game (self-monitoring and competition/comparison version) was more effective for all measures for people in later stage. Specifically, playing tailored version of the game motivated an increase in attitude ($p < 0.0005$), intention ($p < 0.0005$), self-efficacy ($p < 0.0005$), and knowledge ($p < 0.0005$) towards adopting COVID-19 precautionary measures while playing non-tailored version (rewards and suggestion version) led to no significant change in attitude ($p = 0.322$), intention ($p = 0.569$), self-efficacy ($p = 0.257$), and knowledge ($p = 0.624$) for people in later stage.

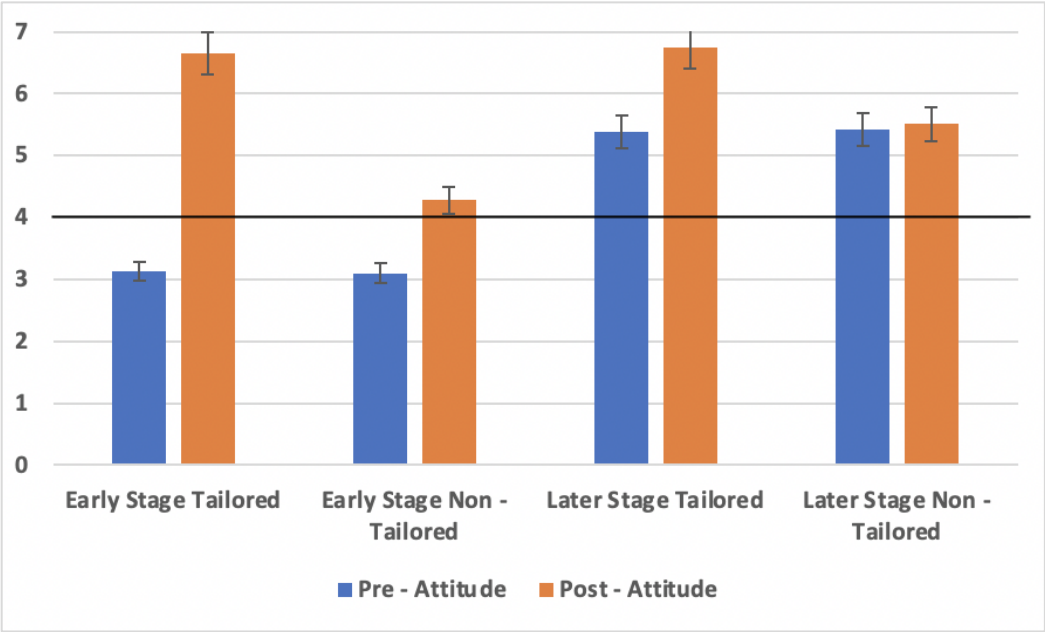


Figure 5.3: Paired means of pre and post attitude by stages of change and intervention type. Error bars represent a 95% confidence interval.

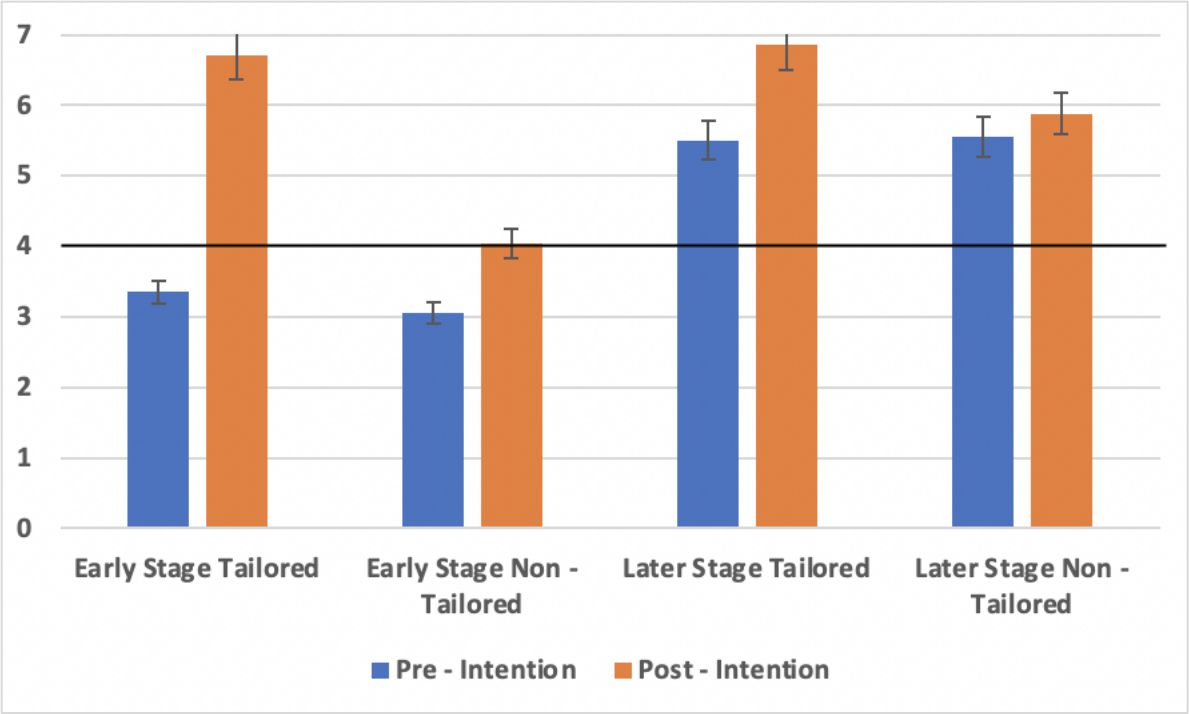


Figure 5.4: Paired means of pre and post intention by stages of change and intervention type. Error bars represent a 95% confidence interval.

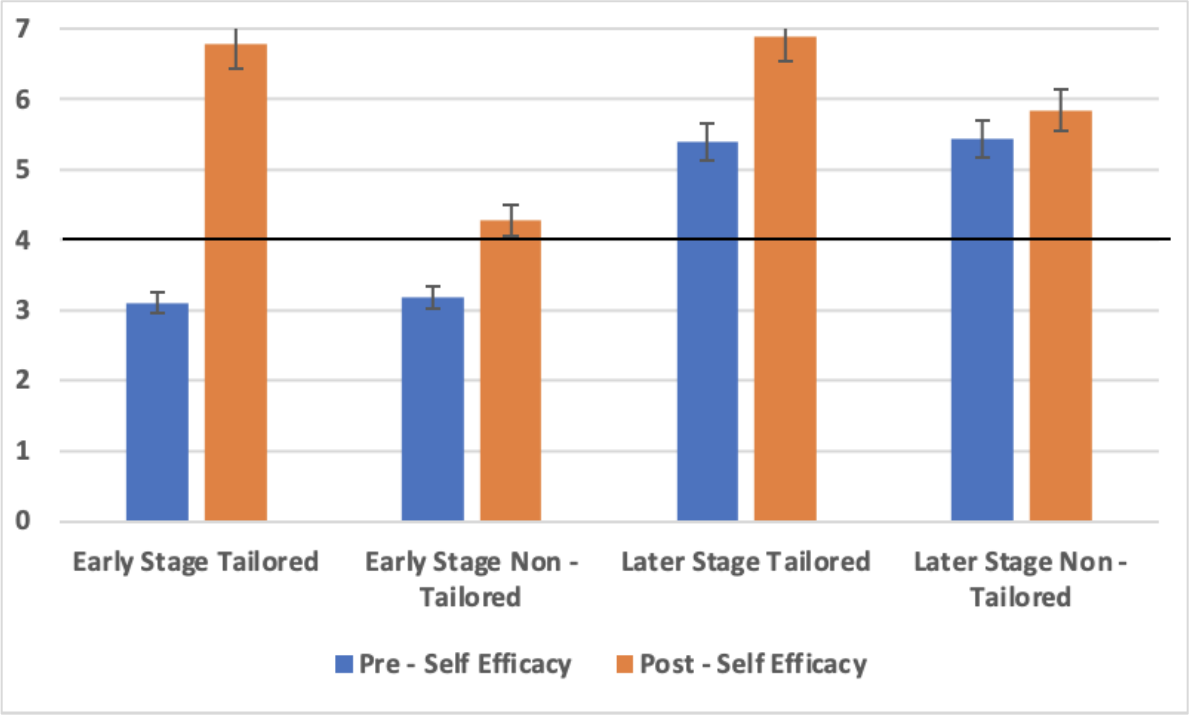


Figure 5.5: Paired means of pre and post self-efficacy by stages of change and intervention type. Error bars represent a 95% confidence interval.

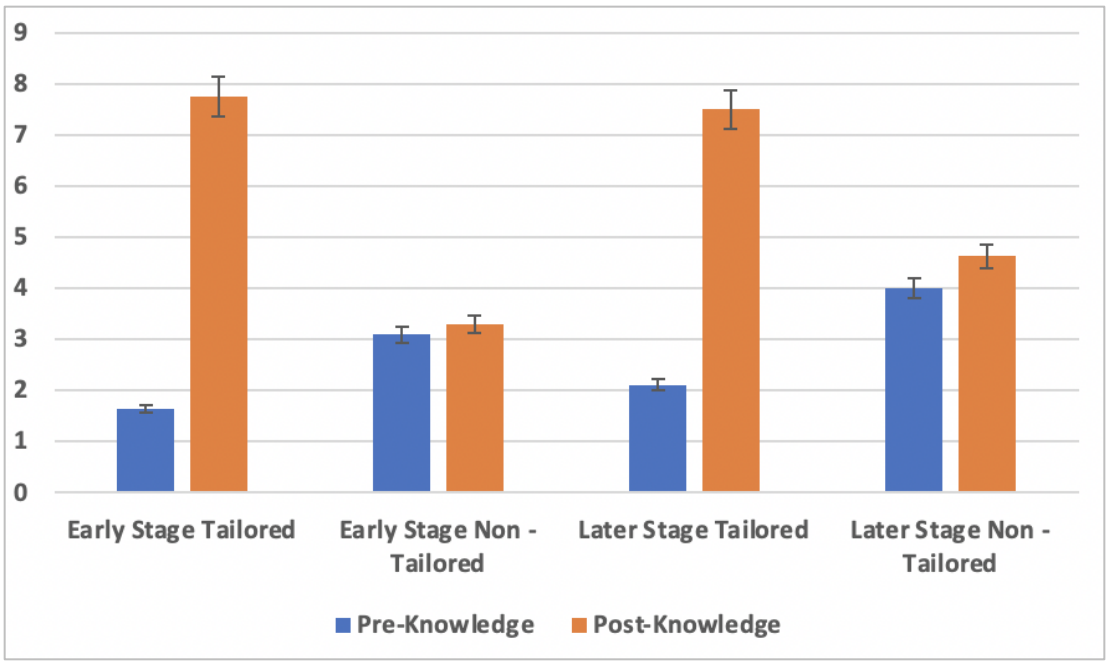


Figure 5.6: Paired means of pre and post knowledge by stages of change and intervention type. Error bars represent a 95% confidence interval.

Table 5.2: Descriptive Statistics (Mean and Standard Deviation) for attitude, intention, and self-efficacy, and knowledge change across Versions

	Version One (N=60)	**Version Two (N=67)**
	Mean ± Standard Deviation	**Mean ± Standard Deviation**
Pre-Attitude	4.35 ± 1.28	4.32 ± 1.25
Post-Attitude	6.04 ± 0.73	5.60 ± 1.27
Pre-Intention	4.52 ± 1.29	4.37 ± 1.36
Post-Intention	6.27 ± 0.67	5.55 ± 1.46
Pre-Self-Efficacy	4.36 ± 1.30	4.38 ± 1.23
Post-Self-Efficacy	6.29 ± 0.70	5.69 ± 1.36
Pre-Knowledge	2.90 ± 2.33	2.57 ± 2.54
Post-Knowledge	6.08 ± 2.06	5.55 ± 2.53

Table 5.3: Descriptive Statistics – Mean (M) and Standard Deviation (SD) for attitude, intention, and self-efficacy change across four intervention groups

	Early Stage		**Later Stage**	
	Tailored (N=28)	**Non-Tailored (N=31)**	**Tailored (N=36)**	**Non-Tailored (N=32)**
	M ± SD	**M ± SD**	**M ± SD**	**M ± SD**
Pre-Attitude	3.13 ± 0.50	3.10 ± 0.53	5.38 ± 0.48	5.42 ± 0.61
Post-Attitude	6.65 ± 0.27	4.28 ± 0.37	6.74 ± 0.27	5.51 ± 0.58
Pre-Intention	3.35 ± 0.65	3.05 ± 0.64	5.50 ± 0.57	5.55 ± 0.70
Post-Intention	6.70 ± 0.35	4.04 ± 0.53	6.85 ± 0.27	5.88 ± 0.66
Pre-Self-Efficacy	3.11 ± 0.56	3.18 ± 0.54	5.40 ± 0.52	5.44 ± 0.59
Post-Self-Efficacy	6.79 ± 0.32	4.28 ± 0.47	6.90 ± 0.28	5.85 ± 0.66
Pre-Knowledge	1.64 ± 1.33	3.10 ± 3.00	2.11 ± 1.99	4.00 ± 2.47
Post-Knowledge	7.75 ± 0.44	3.29 ± 1.84	7.50 ± 0.87	4.63 ± 1.79

Table 5.4: Significant Level of Changes over time for attitude, intention, self-efficacy, and knowledge by Stages of Change and Intervention Type. Significance Level $p<0.05$

	Early Stage		**Later Stage**	
	Tailored	**Non-Tailored**	**Tailored**	**Non-Tailored**
Attitude	0.000	0.673	0.000	0.322
Intention	0.000	0.428	0.000	0.569
Self-Efficacy	0.000	0.417	0.000	0.257
Knowledge	0.000	0.692	0.000	0.624

5.2.7 Qualitative Results to Support our Findings

To support our quantitative results, we analyzed the interview comments for tailored and non-tailored groups from the interviews. For example, participants in Early stage tailored version group had this to say about the rewards and suggestion strategies:

"Collecting rewards made me feel good and strong." (P2)
"It was additive because face masks and hand sanitizers were for more points and I was constantly trying to collect that in every level." (P3)
"I really liked how suggestions were presented after collecting each powerup. I was curious to collect more and learn eventually" (P1)
"Surely suggestions were something that boosted my mind and confidence to follow the measures." (P4)

Also, participants who were in the Later stage non-tailored group who played rewards and suggestions version of the game found these features least important for instigating motivation as they were already aware of the COVID-19 precautionary measures. This was also clearly reflected in our interview comments:

"I think using rewards cannot make someone follow guidelines who already took COVID serious." (P13)
"It affected me in a negative way as I don't want any rewards to follow guidelines, I think everyone should follow it naturally" (P14)
"I think suggestions can be important for someone who recently started following COVID guideline but for me I was already aware about them." (P13)
"Suggestions were good, but I was already aware about them" (P11)

Furthermore, participants in the Later stage tailored version group who played the competition/comparison and self-monitoring version of the game found these features important to keep them motivated to follow precautionary measures. This was also clearly reflected in our interview comments:

"I was really engaged to save my player when my health was down. I think it is important to have health bar in such type of games." (P10)
"It was constantly in my mind that I don't want to lose the health of my player and adhering to this I was following best practices to stay safe." (P6)
"It really made me stick to the game as I wanted to be the person who is always on top." (P6)
"As I mentioned earlier, I wanted my player to be on top of leaderboard and hence I feel it was important." (P11)

Finally, participants in the Early stage non-tailored group found competition/comparison and self-monitoring strategies least important for building motivation among them. This can be seen from their interview comments:

"I think game can be improved by rewarding player if health bar is full or while collecting poweup" (P15)

"I would like to see leaderboard as different option in the game some people just want to learn" (P16)
"I didn't like leaderboard in the game." (P17)

These results show that the **groups who played the tailored version** of the game are **significantly motivated to adopt the COVID-19 precautionary measures** compared to groups who played the non-tailored version. This answers our R1.

5.3 COVID Pacman Motivational Appeal Overall and Across Groups

Along with examining the differences in motivational appeal of COVID Pacman across the intervention groups, investigating the overall motivational appeal is of interest. To achieve this, we performed a One-Sample t-test on the data from playing the different versions of the game and on the combined data to obtain the overall motivational appeal of COVID Pacman. We compared the data against a neutral rating of 4 on a 7-point ARCS' motivation scale. In general, the results of the One-Sample t-test show that the game is effective with respect to the motivational appeal, the overall motivational rating is significant, $t(126)= 10.218$, $p < 0.0005$. In addition, the results show that all the four constructs of ARCS motivational model are significant ($p<0.0005$), see Table 5.5 and Figure 5.7. Overall, the game is effective and could motivate our participants in general to follow the COVID-19 precautionary measures.

Table 5.5: Mean (M), Standard Deviations (SD), Mean Difference (MD), t-values (t_2), and significance levels on a scale from 1(low) to 7(high) for overall motivational appeal.

N = 127					
Motivation Dimensions	**Mean**	**SD**	**MD**	**t_2**	**p**
Attention	5.39	1.43	1.39	10.980	<0.0005
Relevance	5.32	1.50	1.32	9.880	<0.0005
Confidence	5.27	1.48	1.27	9.650	<0.0005
Satisfaction	5.31	1.48	1.31	9.966	<0.0005

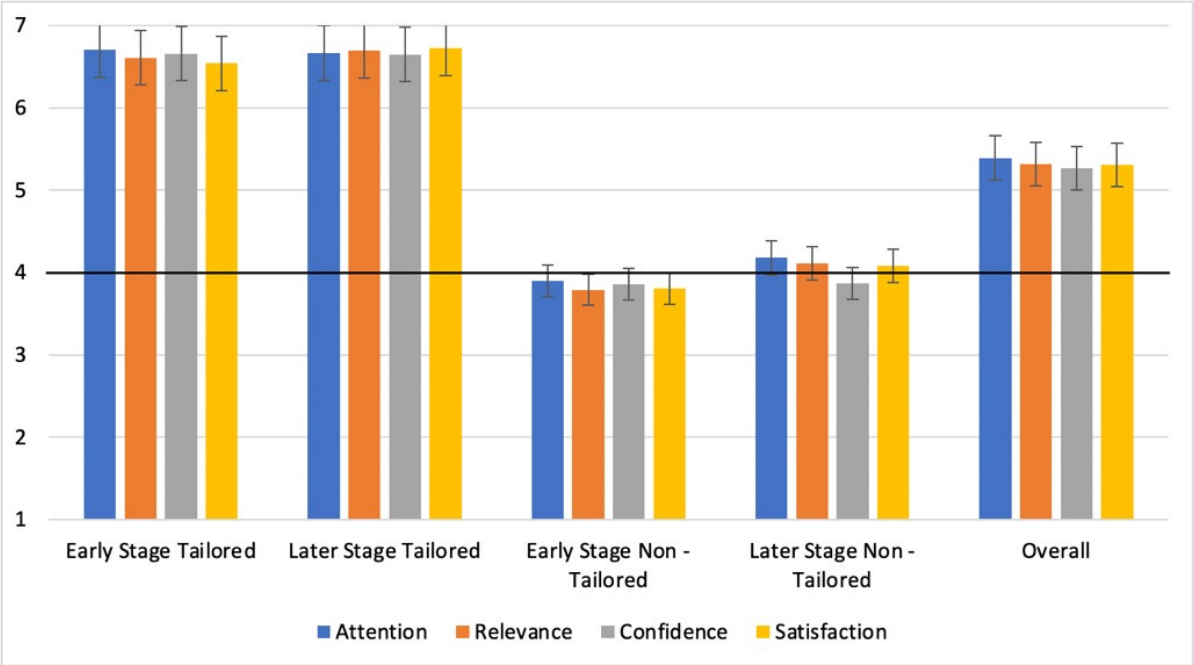


Figure 5.7. A bar chart showing the motivational appeal of the game overall and across the four groups, for the motivation dimensions on a scale ranging from 1 to 7. The horizontal line indicates the neutral score of 4. Error bars represent 95% confidence interval.

The results of a One-Sample t-test for the various intervention groups show that people that played the tailored version of the persuasive game are highly motivated by the game to adopt the COVID-19 precautionary measures with significant mean scores ($p<0.0005$) for all the four ARCS motivation constructs. However, for those that played the non-tailored version, they did not find the game to be significantly motivating, $p > .05$ across the four ARCS motivation constructs, see Table 5.6 and Figure 5.7. This means that the tailored versions of the COVID-19 Pacman are more effective than the non-tailored version, which players found as not motivating.

Table 5.6: Mean (M), Standard Deviations (SD), Mean Difference (MD), t-values (t_2), and significance levels on a scale from 1(low) to 7(high) for four intervention groups.

Motivation Dimensions	**Early Stage**		**Later Stage**	
	Tailored (N=28)	**Non-Tailored (N=31)**	**Tailored (N=36)**	**Non-Tailored (N=32)**
Attention	M=6.71, SD=0.46, MD=2.71, t_2=31.22, p<.0005	M=3.96, SD=0.72, MD= -0.03, t_2= -0.24, p=0.80	M=6.67, SD=0.47, MD=2.66, t_2=33.46, p<.0005	M=4.18, SD=0.60, MD=0.18, t_2=1.75, p=0.09
Relevance	M=6.61, SD=0.34, MD=2.61, t_2=40.30, p<.0005	M=3.79, SD=1.01, MD= -0.20, t_2= -1.15, p=0.25	M=6.70, SD=0.37, MD=2.70, t_2=43.53, p<.0005	M=4.11, SD=0.64, MD=0.11, t_2=1.03, p=0.30

Motivation Dimensions	Early Stage		Later Stage	
	Tailored (N=28)	Non-Tailored (N=31)	Tailored (N=36)	Non-Tailored (N=32)
Confidence	M=6.66, SD=0.54, MD=2.66, t_2=48.93, p<.0005	M=3.86, SD=0.54, MD= -0.13, t_2= -1.42, p=0.16	M=6.65, SD=0.37, MD=2.65, t_2=43.02, p<.0005	M=3.87, SD=0.71, MD=-0.12, t_2=-0.98, p=0.33
Satisfaction	M=6.54, SD=0.38, MD=2.54, t_2=34.79, p<.0005	M=3.81, SD=0.91, MD= -0.18, t_2= -1.10, p=0.27	M=6.73, SD=0.33, MD= 2.73, t_2=48.51, p<.0005	M=4.08, SD=0.60, MD=0.08, t_2=0.78, p=0.43

5.4 Comparing Motivational Appeal of Persuasive Game by Intervention Type (Version One vs Version Two)

The result of a One-Sample t-test on individual versions of the game shows that they are both effective with respect to overall motivation: Version One $t(59)= 7.087$, $p < 0.0005$ and Version Two $t(66)= 7.344$, $p < 0.0005$. They are equally effective across the four motivation dimensions: Version One – Attention ($t(59)= 7.669$, $p < 0.0005$); Relevance ($t(59)= 7.307$, $p < 0.0005$); Confidence ($t(59)= 6.039$, $p < 0.0005$); and Satisfaction ($t(59)= 7.128$, $p < 0.0005$): Version Two – Attention ($t(66)= 7.822$, $p < 0.0005$); Relevance ($t(66)= 6.777$, $p < 0.0005$); Confidence ($t(66)= 7.558$, $p < 0.0005$); and Satisfaction ($t(66)= 7.038$, $p < 0.0005$). Overall, the two versions of COVID Pacman are effective with respect to their motivational appeal.

We conducted an Independent Sample t-test. The results show that there is no significant difference between the two versions of COVID Pacman with respect to their motivational appeal, $t(125)= -0.439$, $p = 0.661$. Overall, Version One ($M = 5.26$, $SD = 1.38$) of COVID Pacman which is based on reward and suggestion is equally effective when compared to Version Two ($M = 5.38$, $SD = 1.53$) which is based on self-monitoring and competition/comparison with respect to their motivational appeal. The results of the Independent Sample t-test also show that people who played the self-monitoring and competition/comparison version of the game (Version Two) rated it equally across the four constructs of motivation compared to those that played the reward and suggestion version (Version One), as shown in Figure. 5.8. These results imply that without considering the stages of change, self-monitoring and competition strategies are not significantly different from reward and suggestion strategies in their effectiveness when employed in persuasive games design. The results suggest that self-monitoring and competition is equally effective when compared to reward and suggestion for motivating behaviour change overall and for attracting and

retaining Attention, increasing the Relevance of an intervention, increasing people's Confidence, and their Satisfaction with the intervention in line with the ARCS model. However, considering the stages of change shows the effectiveness of the strategies depends on an individual's stage of behaviour change.

Table 5.7: Mean (M), Standard Deviations (SD), Mean Difference (MD), t-values (t_2), and significance levels on a scale from 1(low) to 7(high) for both versions.

Motivation Dimensions	Version One (Reward and Suggestion)					Version Two (Self-monitoring and Competition/Comparison				
	M	SD	MD	t_2	p	M	SD	MD	t_2	p
Attention	5.36	1.38	1.36	7.669	<0.0005	5.41	1.48	1.41	7.822	<0.0005
Relevance	5.28	1.36	1.28	7.307	<0.0005	5.35	1.63	1.35	6.777	<0.0005
Confidence	5.17	1.51	1.17	6.039	<0.0005	5.36	1.47	1.36	7.558	<0.0005
Satisfaction	5.23	1.34	1.23	7.128	<0.0005	5.38	1.60	1.38	7.038	<0.0005

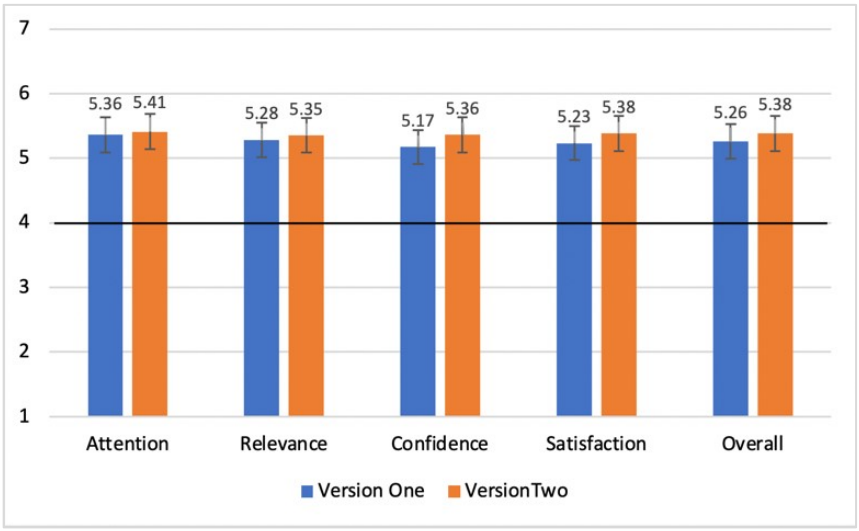


Figure 5.8: Comparative motivational appeal of the two game versions overall and for the motivation dimensions on a scale ranging from 1 to 7. The horizontal line indicates the neutral score of 4. Error bars represent 95% confidence interval.

5.5 Comparing Motivational Appeal of Persuasive Game Versions Across the Stages of Change

To compare the effectiveness of the tailored versus non-tailored game intervention with respect to their effectiveness for people at different stages of change, we divided our participants into four sub-groups: (1) Early stage tailored version, (2) Later stage tailored version, (3) Early stage non-tailored version, and (4) Later stage non-tailored version. To compare the overall motivational appeal of the game across the four groups, first, we computed the average motivation score

separately for each motivation dimensions. We also obtained a combined average motivation score (that combines the averages from each motivation dimension) from various groups. Next, we conducted a One-Way ANOVA with the stages of change (early stage tailored, later stage tailored, early stage non-tailored, later stage non-tailored) and intervention type (Version One, Version Two) as the between-subject factor.

5.5.1 Comparing Overall Motivational Appeal Across the Stages of Change

Interaction between Intervention Type and Stages of Change: The results of the One-Way ANOVA show there are statistically significant differences between the groups ($F(3,123) = 257.089$ $p < 0.0005$) with respect to the overall motivational appeal of the game. A post hoc test revealed that the tailored versions of the persuasive game were more effective than the non-tailored versions overall. Participants in the Early stage of behaviour change who played their tailored version found the game to be more motivating overall compared to those in the Early stage who played their non-tailored version ($p = .0005$). Similarly, participants in the Later stage of behaviour change who played their tailored version found the game to be more motivating overall compared to those in the Later stage of behaviour change who played the non-tailored version ($p = .0005$). Figure 5.9 shows a graph comparing the overall motivation score of tailored and non-tailored for people at various behaviour change stages.

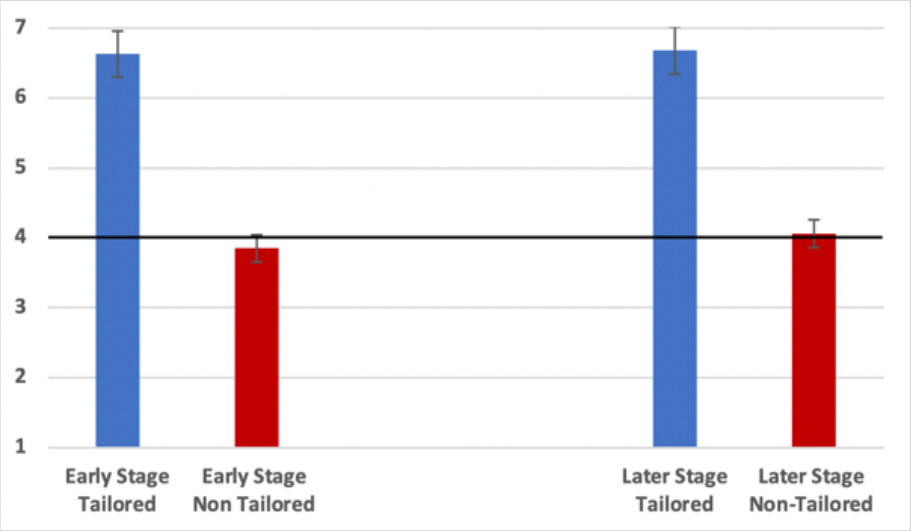


Figure 5.9: Comparing the mean of the motivational appeal of the of the tailored versus non-tailored version on a scale ranging from 1 to 7. The horizontal line indicates the neutral score of 4. Error bars represent 95% confidence interval.

5.5.2 Comparing Motivational Appeal Based on Four Dimensions of Motivation Across the Stages of Change

Interaction between Intervention Type and Stages of Change: The results of the One-Way ANOVA (see Table 5.12) show there is statistically significant difference between the intervention groups, across the four dimensions of motivation: Attention $F(3,123) = 216.457$ $p < 0.0005$); Relevance $F(3,123) = 187.021$ $p < 0.0005$); Confidence $F(3,123) = 318.708$ $p < 0.0005$); and Satisfaction $F(3,123) = 213.764$ $p < 0.0005$). A post hoc test revealed that the tailored versions of the persuasive game were more effective than the non-tailored version for all the four dimensions of motivation. Participant in the Early stage of behaviour change who played their tailored version found the game to be more motivating compared to those in the Early stage who played their non-tailored version: Attention ($p = .0005$); Relevance ($p = .0005$); Confidence ($p = .0005$); and Satisfaction ($p = .0005$). Similarly, participants in the Later stage of behaviour change who played their tailored version found the game to be more motivating compared to those in the Later stage of behaviour change who played the non-tailored version across the four motivation dimensions of motivation; Attention ($p = .0005$); Relevance ($p = .0005$); Confidence ($p = .0005$); and Satisfaction ($p = .0005$).

Table 5.8: The Results of One-Way ANOVA for the Four Dimensions of Motivation

Motivation Dimensions	**Results**
Attention	$F(3,123) = 216.457$, $p = .0005$
Relevance	$F(3,123) = 187.021$, $p = .0005$
Confidence	$F(3,123) = 318.708$, $p = .0005$
Satisfaction	$F(3,123) = 213.764$, $p = .0005$

Therefore, we can conclude that **COVID Pacman is effective overall with respect to motivational appeal** for promoting COVID-19 precautionary measures. Further our results also show that **motivational appeal of COVID Pacman is higher among the participants who played tailored version**s as compared to non-tailored versions. This answers our R2.

5.6 COVID Pacman Overall Player Experience

To understand the experience of the player while playing COVID Pacman, we employed popular Intrinsic Motivation Inventory (IMI) scale [164]. Using a 7-point Likert scale, we collect players' play experience data based on 5 variables. They are:

The level of *interest and enjoyment* players experienced while playing COVID Pacman.

The level of players' *perceived competence* in the game.

The level of *effort and importanc*e the player attached to the game.

The level of *pressure and tension* experienced by the player while playing the game.

The level of *value and usefulness* the player attached to the game.

We measured the level of Interest and Enjoyment of COVID Pacman by participants using 5 questions on a 7-point Likert scale, ranging from 1 (strongly disagree) to 7 (strongly agree), after playing the COVID Pacman game. To analyze the play experience from playing the game, we conducted a one-sample t-test with an optimistic neutral point/mid-point of 4. We examined if the mean score for all variables from participants was significant. Table 5.9 shows the statistical results for one-sample t-test for each of the variables under player experience.

Table 5.9: Mean (M), Standard Deviations (SD), Mean Difference (MD), t-values (t_2), and significance level on a scale from 1(low) to 7(high) for IMI sub scales.

N=127					
Dimensions	**M**	**SD**	**MD**	**t_2**	**p**
Interest and Enjoyment	5.06	1.43	1.06	8.40	p<0.0005
Perceived Competence	5.48	1.34	1.48	12.44	p<0.0005
Effort/Importance	5.28	1.38	1.28	10.44	p<0.0005
Pressure/Tension	2.72	1.26	-1.27	-11.29	p<0.0005
Value/Usefulness	5.55	1.39	1.54	12.48	p<0.0005

Our results from one-sample t-test show that, COVID Pacman instigated significantly high interest and enjoyment ($t(126) = 8.40$, $p < 0.0005$), Perceived Competence ($t(126) = 12.44$, $p < 0.0005$), Effort/Importance ($t(126) = 10.44$, $p < 0.0005$), and Value/Usefulness ($t(126) = 12.48$, $p < 0.0005$). However, it was also clear from the results that COVID Pacman generated significantly low pressure and tension ($t(126) = -11.29$, $p < 0.0005$).

5.7 Examining COVID Pacman Player Experience by Stages of Change and Intervention Type

We conducted a two-way ANOVA with stage of change (early stage and later stage) and intervention type (version one and version two) as between-subject factors and play experience (interest-enjoyment, perceived competence, effort-importance, pressure-tension, value-usefulness) as dependent measures.

5.7.1 Interest-Enjoyment

The result show no significant main effects of stages of change or intervention type on interest-enjoyment ($F_{123} = 0.005$, $p = 0.943$, $\eta^2 = 0.000$) and ($F_{123} = 0.155$, $p = 0.694$, $\eta^2 = 0.001$) when considered separately, suggesting that there were no overall group differences on how people at different stages of change enjoyed the games or different interventions (game versions). However, there was a significant interaction between the stages of change and intervention type ($F_{123} = 255.012$, $p < 0.0005$, $\eta^2 = 0.675$). Pairwise comparison shows that players in early stage who played the tailored version (version one) of the game experienced higher enjoyment ($p < 0.0005$) than those who played the non-tailored version (version two) ($p = 0.243$). Similarly, players in later stage who played their tailored version (version two) of the game experienced higher enjoyment ($p < 0.0005$) than those who played the non-tailored version (version one) ($p = 0.462$). This result is in line with our hypothesis that tailoring the persuasive game to individual's stages of change will lead to a significant increase in play experience.

5.7.2 Perceived Competence

Similar to interest-enjoyment, the result show no significant main effects of stages of change or interventions type on competence ($F_{123} = 2.093$, $p = 0.151$, $\eta^2 = 0.017$) and ($F_{123} = 0.119$, $p = 0.730$, $\eta^2 = 0.001$) respectively when considered separately. However, there was a significant interaction between the stages of change and intervention type ($F_{123} = 385.972$, $p < 0.0005$, $\eta^2 = 0.758$). Pairwise comparison shows that players in early stage who played the tailored version (version one) ($p < 0.0005$) led to higher feelings of competence than those who played the non-tailored version (version two) ($p = 0.751$); whereas for players in the later stage, playing tailored version (version two) ($p < 0.0005$) of the game led to higher feelings of competence than those who played non-tailored version (version one) ($p = 0.296$) of the game. Again, these results confirmed our hypothesis that tailoring the persuasive games to individual's stages of change will lead to a significant increase in play eperience.

5.7.3 Effort-Importance:

Similar to perceived competence, the result show no significant main effects of stages of change or interventions type on effort-importance ($F_{123} = 0.531$, $p = 0.468$, $\eta^2 = 0.004$) and ($F_{123} = 0.121$, $p = 0.729$, $\eta^2 = 0.001$) respectively when considered separately. However, there was a significant interaction between the stages of change and intervention type ($F_{123} = 410.892$, $p < 0.0005$, $\eta^2 = 0.770$). Pairwise comparison shows that players in early stage who played tailored version of the game (version one) ($p < 0.0005$) led to higher feelings of effort-importance than those who played the non-tailored version (version two) ($p = 0.596$); whereas players in later stage who played tailored version of the game (version two) ($p < 0.0005$) led to higher feelings of effort-importance than those who played the non-tailored version (version one) ($p = 0.612$).

5.7.4 Value-Usefulness:

Similar to effort-importance, the result show no significant main effects for stages of change or interventions type on value-usefulness ($F_{123} = 2.835$, $p = 0.095$, $\eta^2 = 0.023$) and ($F_{123} = 0.017$, $p = 0.897$, $\eta^2 = 0.000$) respectively when considered separately. However, there was a significant interaction between the stages of change and intervention type ($F_{123} = 440.996$, $p < 0.0005$, $\eta^2 = 0.782$). The result also shows that players in early stage who played tailored version (version one) ($p < 0.0005$) of the game experienced higher realization of value-usefulness than those who played the non-tailored version of the game (version two) ($p = 0.374$); whereas players in later stage who played tailored version (version two) ($p < 0.0005$) of the game experienced higher realization of value-usefulness than those who played non-tailored version (version one) ($p = 0.671$) of the game.

5.7.5 Pressure-Tension

In this case, the result show no significant main effects for stages of change ($F_{123} = 3.588$, $p = 0.061$, $\eta^2 = 0.028$) when considered separately. Also, there was no significant interaction between the stages of change and intervention type ($F_{123} = 0.368$, $p = 0.545$, $\eta^2 = 0.003$). However, the result show significant main effects for intervention types ($F_{123} = 4.954$, $p < 0.05$, $\eta^2 = 0.039$) when considered separately. Pairwise comparison results show that overall version one of the game was perceived as causing more pressure-tension among the players as compared to playing version two. The differences were significant at $p < 0.05$.

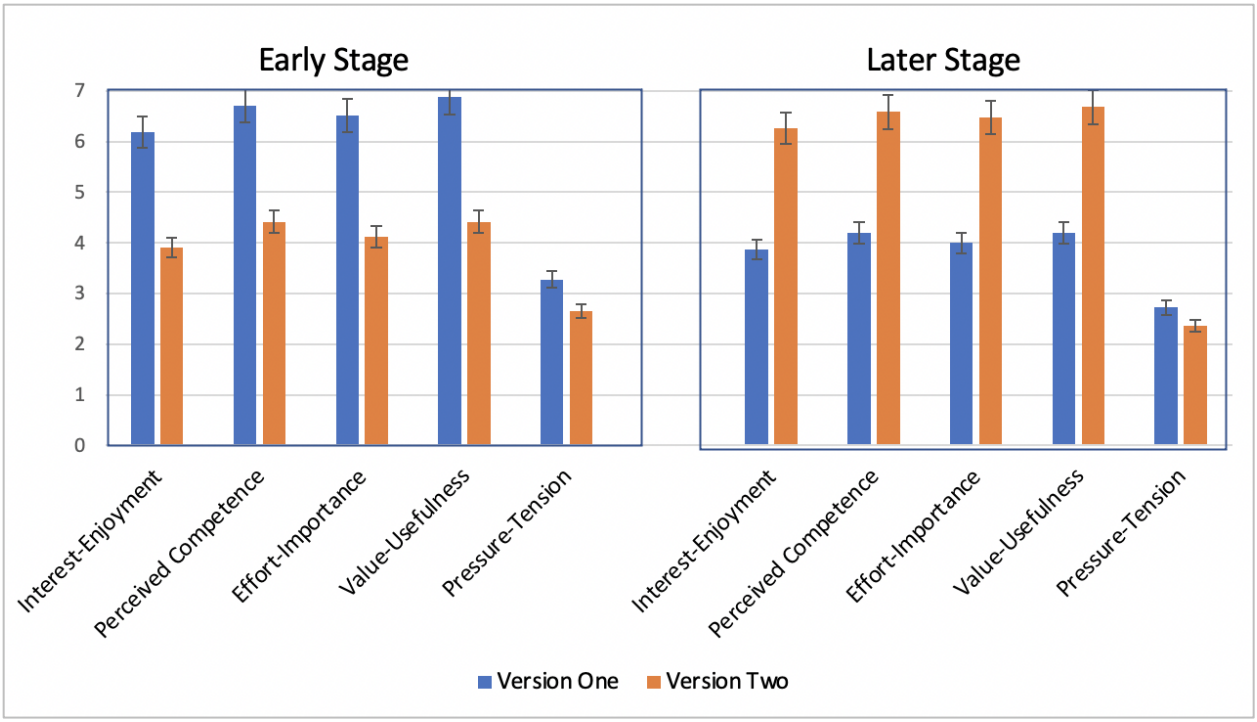


Figure 5.10: Paired Mean of Individual IMI subscale. By intervention type. Error bars represent a 95% confidence interval.

We can therefore conclude that players had a **positive play experience** from playing COVID Pacman. This answers our R3. However, **playing the tailored version led to higher positive experience overall and across the player experience** dimensions than the non-tailored version. This answers our R4.

5.8 Perceived Persuasiveness

We measured the persuasiveness of COVID Pacman, using 5 questions on a 7-point Likert scale, ranging from 1 (strongly disagree) to 7 (strongly agree), after the participants played the game.

To analyze the persuasiveness of the game, we conducted a one-sample t-test. This was done to determine if the persuasiveness score of the participants was significantly higher than the neutral value of 4. Our results show that the COVID Pacman was perceived to be significantly persuasive among the participants ($t(126) = 33.739$, $p < 0.0005$).

Table 5.10: Mean (M), Standard Deviations (SD), Mean Difference (MD), t-values (t_2), and significance level on a scale from 1(low) to 7(high) for Perceived Persuasiveness of COVID Pacman

N=127					
Dimensions	**M**	**SD**	**MD**	**t_2**	**p**
Persuasiveness	6.25	0.75	2.25	33.739	P<0.0005

We can, therefore, conclude that **COVID Pacman was perceived to be persuasive** with respect to the ability to promote the adoption of COVID-19 precautionary measures. In other words, the game has the ability to persuade people to follow COVID-19 precautionary measures. This answers our R5.

5.9 Qualitative Analysis

After the post-test survey, we conducted one-to-one interviews with 18 participants. We audio-recorded all of the interviews with the participants' permission. From the interview recordings we transcribed the data and analyzed the comments that were made in the interview from the participants. We collected qualitative data by interviewing 18 participants overall from the four intervention groups (Early stage tailored (N=5), Later stage tailored (N=5), Early stage non-tailored (N=4), Later stage non-tailored (N=4)). The purpose of the interview was to collect qualitative data about the participants' opinion about the game. Different questions were asked to the participants to get more insight on learnings from the game, impact of the game on their behaviour, importance of the persuasive features that were used in the different game versions, their overall game experience, and feedback for improvements and suggestions. We analyzed the interview responses according to the questions asked from the participatns in different intervention groups as well as we also performed the thematic analysis on the overall comments to bring out some specific themes from the responses.

Following sections describe more about the summary of outcomes from each interview questions with the sample comments from the participants. Finally, we also present the results of thematic analysis of the survey and interview comments.

5.9.1 Learning from COVID Pacman

To understand the participants' learning from the game, we asked them the question "What did you learn about COVID from playing the game?" We got different responses from participants in

different groups. People who played tailored versions were really curious to play and learned a lot from playing the game. However, people who played the non-tailored versions were either not satisfied or didn't learn anything new. The reason for this may be because the version was not tailored according to their stages of change. For example, people in early stage tailored groups were motivated to follow precautionary measures while people in later stage tailored groups also found the game as an important reminder to keep following the measures in their lifestyle. Below Table 5.11 shows the sample comments from the participants for each of the groups.

Table 5.11: Sample Comments with respect to learning from game across the four groups

Groups	**Sample Comments**
Early Stage Tailored	*"Earlier I used to ignore but after playing the game it was clear that covid is a serious disease and we need to prepare ourselves for new normal" (P2)* *"I realized my mistake of ignoring precautionary measures after playing the game. Seeing the infection spread made me aware of the problem and I will improve my habit for sure." (P4)*
Later Stage Tailored	*"I learned that we can recover from COVID if closely monitor our health and take safety measures." (P6)* *"Until this game I was following measures out of fear, but this made me realize that we should follow it to stay safe and it really takes less time and effort to involve this in our lifestyle." (P10)*
Early Stage Non-Tailored	*"Playing the game didn't affect me to be careful about guidelines for COVID. I live in a city where no one is following guidelines." (P18)*
Later Stage Non-Tailored	*"I would not say I learned but yes definitely reminded about the safety measures for covid" (P12)* *"Nothing much as I was already aware about the COVID safety measures and have been practicing it" (P13)*

5.9.2 Raising awareness about COVID after playing the game

To understand the participants' awareness about COVID-19 after playing the game, we asked them the question "Did the game raise your awareness about COVID-19 and how?" We got different responses from participants in different groups. Overall, we saw that people who play tailored versions were more aware and more vigilant to follow COVID-19 precautionary measures as compared to people who played non-tailored versions. For example, people in early stage tailored groups stated that they have started practicing social distancing and other measures in their life following the game as it helped raise awareness. Also, people in later stage tailored groups recalled

this game as an important wakeup call to keep practicing these measures. However, people in early stage non-tailored groups were expecting something basic information about the disease. Also, people in later stage non-tailored groups stated that they are following the COVID-19 measures from start of the pandemic and the game didn't actually increase any awareness about the pandemic as they are already aware about them. Table 5.12 shows the sample comments from the participants for each of the groups.

Table 5.12: Sample Comments with respect to awareness about COVID-19 after playing the game across the four groups

Groups	**Sample Comments**
Early Stage Tailored	*"After playing the game I try to sanitize my hands frequently and always wear face mask." (P2)* *"I became more aware while visiting crowded places nowadays and I follow social distancing." (P4)*
Later Stage Tailored	*"Yes, I always follow measures, but this game was an important reminder for me to not stop what I am doing." (P8)* *"Yes, although I am already aware of the guidelines but yes game was really was a good wakeup call in this journey." (P10)*
Early Stage Non-Tailored	*"Yes, it did but as I said it will good if it starts with basic as opposed to directly involving leaderboard" (P16)* *"not anything significant" (P18)*
Later Stage Non-Tailored	*"I don't think so. I think me and my family are staying safe from the start of the pandemic" (P12)* *"I am already aware of the guidelines and I don't think people who already know about it (guidelines) are going to get more information." (P11)*

5.9.3 Impact on participants' behaviour regarding following COVID measures after playing the game

To understand the impact on participants' behaviour about adhering to COVID precautions after playing the game, we asked them the question "Did the game make you reflect on COVID-19 and how?" We got different responses from participants in different groups. Overall, it was clear from the responses that game created a positive impact on the behaviour of the participants in the tailored groups as compared to non-tailored groups. For example, participants in Early stage tailored group mentioned that the game affected and changed their attitude towards COVID-19 and made them more cautious to follow precautionary measures. Similarly, participants in Later stage tailored

groups mentioned that the game supported their behaviour which they are already following in their daily life. Table 5.13 shows the sample comments from the participants for each of the groups.

Table 5.13: Sample Comments with respect to impact on participants' behaviour after playing the game across the four groups

Groups	**Sample Comments**
Early Stage Tailored	*"It changed my way of attitude towards COVID. It made me more cautious to stay protected and protect myself as well as others." (P1)* *"The game definetely gave me a though of how I was living in this pandemic now and that I need to start considering precautions now immediately." (P4)*
Later Stage Tailored	*"It made me support my behavior that I have been following already. Thanks to developers of this game." (P6)* *"Strong support that I got realizing that covid is still here and we have to stay safe and keep continuing the steps that we are taking." (P8)*
Early Stage Non-Tailored	"*Playing the game was really good but it will be better if we can get more information and learnings from the game rather than just competing with others*" (P17)
Later Stage Non-Tailored	"*I don't think so as I am already a follower of all guidelines."* (P14)

5.9.4 Impact of Rewards in the game

To understand the impact of rewards implementation in the game on participants, we asked them the question "How did the rewards offered in the game impact how you played the game?" We collected responses only from the groups who played the game version that implemented rewards (Version One). Participants in the early stage tailored group found rewards as an important factor for extrinsic motivation to keep playing the game. However, people in the later stage non-tailored groups found rewards pointless and highlighted it may negatively impact on their gameplay as they believe in following COVID-19 precautions should be natural and intrinsic. Table 5.14 shows the sample comments from the participants for each of the groups.

Table 5.14: Sample Comments with respect to impact of Rewards in the game

Groups	**Sample Comments**
Early Stage Tailored	*"Honestly, it was the only reason the kept me tied to the game during initial days." (P1)*

	"It was important to collect rewards as I was constantly being chased by covid virus and rewards helped me to stay safe from them by giving extra points and thus extra lives." (P5)
Later Stage Non-Tailored	*"I think using rewards cannot make someone follow guidelines who already took COVID serious" (P13)* *"In a negative was as I don't want any rewards to follow guidelines, I think everyone should follow it naturally" (P14)*

5.9.5 Impact of Suggestions about COVID precautionary measures in the game

To understand the impact of suggestions on participants, we asked them the question "How did the suggestions about COVID-19 precautionary measures impact how you played the game?" We collected responses only from the groups who played the game version with suggestions (Version One). Participants in the Early stage tailored groups found suggestions to be extremely useful and were curious to learn more about the COVID-19 precautionary measures. However, participants in Later stage non-tailored group were of the opinion that they are already aware about them and it might be helpful for people who have no knowledge or have recently started practicing COVID-19 precautionary measures. Table 5.15 shows the sample comments from the participants for each of the groups.

Table 5.15: Sample Comments with respect to impact of Suggestions about COVID precautionary measures in the game

Groups	**Sample Comments**
Early Stage Tailored	*"I really liked how suggestions were presented after collecting each powerup. I was curious to collect more and learn eventually." (P1)* *"Suggestions were important for learning about the hand sanitizers, face masks, and other things to stay protected." (P2)*
Later Stage Non-Tailored	*"Suggestions were good, but I was already aware about them" (P11)* *"I can see it can be important for someone recently started following COVID guideline but for me I was already aware about them." (P13)*

5.9.6 Impact of Self-monitoring in the game

To understand the impact of suggestions on participants, we asked them the question "How did the health bar monitoring impact on how you played the game?" We collected responses only from the groups who played the game version with self-monitoring (Version Two). Participants in the

later stage tailored groups found health bar really engaging and important as they were able to constantly monitor their health status from the infection. However, participants in the Early stage non-tailored groups expressed the need for some rewards to motivate them to maintain good health. Table 5.16 shows the sample comments from the participants for each of the groups.

Table 5.16: Sample Comments with respect to impact of Self-monitoring in the game

Groups	**Sample Comments**
Later Stage Tailored	*"It was constantly in my mind that I don't want to lose the health of my player and adhering to this I was following best practices to stay safe." (P6)* *"I was really engaged to save my player when my health was down. I think it is important to have health bar in such type of games." (P10)*
Early Stage Non-Tailored	*"I think it can be improved by rewarding player if health is full or while collecting powerups." (P15)*

5.9.7 Impact of Competition/Comparison (Leaderboard) in the game

To understand the impact of competition/comparison on participants after playing the game, we asked them the question "How did leaderboard impact how you played the game?" We collected responses only from the groups who played the game version with Competition / Comparison (Version Two). Participants in the Later stage tailored groups found the leaderboard of competition as a very exciting feature of the game as this made them play the game again and again. However, participants in the Early stage non-tailored groups found this feature to be less useful and were interested more in learning rather than competing. Table 5.17 shows the sample comments from the participants for each of the groups.

Table 5.17: Sample Comments with respect to impact of Competition/Comparison (Leaderboard) in the game

Groups	**Sample Comments**
Later Stage Tailored	*"It really made me stick to the game as I wanted to be the person who is always on top." (P6)* *"Oh yes I am still playing the game on weekends and free time to be on top of leaderboard." (P9)*
Early Stage Non-Tailored	*"I would like to see leaderboard as different option in the game some people like me just want to might learn." (P16)*

5.9.8 Thematic Analysis from Survey Comments and Interviews

For collecting the qualitative comments from the post-survey, we asked the participants to provide justifications/comments about their experience with the game and to justify their ratings. Table 5.18 presents the themes identified in the thematic analysis of the survey comments along with the sample comments from the participants.

Table 5.18: Themes, Descriptions, and sample comments from online survey

1. Useful and relevant game content – Participant found the game content useful and relevant with respect to promoting the adoption of COVID-19 precautionary measures. *"This game is useful to me as it is regarding covid measures that everyone should follow."* (P5) *"The content of the game is relevant and makes sense to me as it provides the means to avoid the spread of the COVID."* (P11) *"The game displays and promotes useful and relevant content."* (P40)
2. Creating awareness and impacting knowledge about COVID-19 precautionary measures – The game helped in raising awareness and impacting knowledge about COVID-19 precautionary measures. *"Does a great job of creating Covid measures awareness."* (P3) *"The game would improve my awareness in the adoption of Covid precautionary measures."* (P30) *"I felt that the game was a good experience to play as it is raising awareness."* (P46) *"This game would be useful to me to increase my knowledge about COVID spread."* (P6) *"The knowledge regarding the COVID precautionary measures is presented in this game."* (P22)
3. Easy to play and aesthetically appealing User Interface (UI) – Our participant found the game easy to play, and participants liked the user interface of the game and the overall pacman theme. *"The UI of the game is quite compelling, and it reminds of the older games we played. So, it's good game to play."* (P1) *"The Pacman theme in itself is quite nostalgic and enjoyable."* (P52) *"The game was easy to understand and play."* (P61)

After all the participants completed the COVID Pacman and responded to the post survey; we interviewed 18 of them (Early stage tailored: n=5, Later stage tailored: n=5, Early stage non-tailored: n=4, Later stage non-tailored: n=4) one-to-one to collect more qualitative insight about the game and their experience. This provided deeper insights that support our findings. Table 5.19 presents relevant identified themes and sample comments from one-to-one interview.

Table 5.19: Themes, Descriptions, and sample comments from one-to-one interview

1. Self-realization on the importance of following the COVID precautionary measures – The game made the players realize how important it is to follow the precautionary measures via the simulation and narratives.

"Earlier, I used to ignore but after playing the game it was clear that covid is a serious disease and we need to prepare ourselves for new normal" (P2)
"Until this game I was following measures out of fear, but this made me realize that we should follow it to stay safe and it really takes less time and effort to involve this in our lifestyle." (P10)
"I realized my mistake of ignoring precautionary measures after playing the game. Seeing the infection spread made me aware of the problem and I will improve my habit for sure." (P4)

2. Encouraged engagement in behaviours that are in line with the COVID-19 precautionary measures – Playing the COVID Pacman game encouraged desired behaviours while discouraging others, in line with the COVID-19 precautionary measures.

"After playing the game I try to sanitize my hands frequently and always wear face mask." (P2)
"I became more aware not to visit crowded places nowadays and I follow social distancing." (P4)

3. Support for the reward strategy –The reward strategy helped participants to visualize their score in the form of game points and they found it motivating.

"Collecting rewards made me feel good and strong." (P2)
"It was additive because face masks and hand sanitizers were for more points and I was constantly trying to collect that in every level." (P3)

4. Support for the suggestion strategy –The suggestion strategy helped participants to understand the importance of COVID precautionary measures and why they should obey them using tips/suggestions in the game.

"I really liked how suggestions were presented after collecting each powerup. I was curious to collect more and learn eventually." (P1)
"Surely suggestions were something that boosted my mind and confidence to follow the measures." (P4)

5. Support for the self-monitoring strategy – The self-monitoring strategy which help participants track their health status using health bar helped to engage and motivate the participants.

"I was really engaged to save my player when my health was down. I think it is important to have health bar in such type of games." (P10)
"It was constantly in my mind that I don't want to lose the health of my player and adhering to this I was following best practices to stay safe." (P6)

6. Support for the competition/comparison strategy – Participants highlighted the importance of competition/comparison strategy in the game in keeping them engaged as they compare their scores with others on leaderboard and try to stay on top.

"It really made me stick to the game as I wanted to be the person who is always on top." (P6)
"As I mentioned earlier, I wanted my player to be on top of leaderboard and hence I feel it was important." (P11)

7. Liking for overall game design and sound effects – Participants portrayed liking towards game UI design and sound effects.

"I enjoyed the simplistic design of the game." (P2)
"I liked the UI and sound effects." (P10)
"I liked the Icons, and the way information was presented in an interactive way." (P3)

8. Suggestions for expanding scope of the game – Participants suggested some improvements and future work including designing the game to accommodate multiple diseases and their prevention as different modes in the game.

"I think the game can include multiple modes for different types of diseases but when it comes to covid game was sufficient." (P10)
"Including another version for another COVID-19 strains when more information is available will be useful thing to add." (P1)

In summary, **thematic analysis results are in line with our quantitative results of the game**. The feedback demonstrates that the game created awareness and motivated participants to adhere to the COVID-19 precautionary measures. Moreover, the comments from the participants also portrayed positive learnings from the game, positive impact on their behaviour, and corroborates that persuasive features used in the game are important, useful, and effective.

6 CHAPTER 6 DISCUSSION

In this chapter, we summarized our research findings by discussing the implication of our results.

It is very appealing in the absence of knowledge to assume that random implementation of persuasive strategies in the behaviour change games would motivate the desirable behaviour irrespective of the individual's stage of change. Our research investigated this hypothesis that *tailoring the underlying persuasive strategies in persuasive games for behaviour change based on the individual's stage of change would effectively motivate behaviours to adopt COVID-19 precautionary measures.* In our study, we designed and implemented two different version of the COVID Pacman game to motivate the adoption of COVID-19 precautionary measures. We used Reward and Suggestion strategies in Version One and employed Self-monitoring and Competition/Comparison strategies in Version Two. Version One and Version Two of the game were tailored according to the needs of people in early stage of TTM and later stage of TTM respectively. In summary, our results show that groups who played the tailored version of the game were positively motivated as compared to the groups who played the non-tailored version.

Our results also show that the game was effective overall, in promoting the adherence to COVID-19 precautionary measures. This is in line with the qualitative comments from our participants. For example, one of the participants in the interview said:
"Earlier I used to ignore but after playing the game it was clear that covid is a serious disease and we need to prepare ourselves for new normal." (P2)

This supports our findings that the game was successful in motivating the participants to adhere to COVID-19 precautionary measures. Again, the comments also provide support for the importance of digital interventions as a tool for health promotion and disease prevention especially those that create opportunities to simulate and visualize the cause-and-effect linkage of unhealthy and non-compliant behaviours such as digital games. This type of game is powerful and has the capability to persuade beyond what conventional health and risk communication intervention can afford using appealing visual cues that can be easily understandable by many. It allows people to rehearse and experiment with unhealthy behaviour and see the consequences in a safe space. Our results show that such experimentations such as breaking the social distancing rule and observing the consequences in the digital space are highly motivating: *"I realized my mistake of ignoring*

precautionary measures after playing the game. Seeing the infection spread made me aware of the problem and I will improve my habit for sure." (P4)

Moreover, it was clear from the interview comments that the persuasive features in the game were important for facilitating the behaviour change. Finally, our findings from thematic analysis also showed that reward, suggestion, self-monitoring, and competition/comparison are important persuasive strategies to be considered by persuasive researchers while designing interventions in the domain of disease prevention, however, their appeal and effectiveness may vary depending on the stage of change of an individual.

6.1 Relative and Comparative Effectiveness of Persuasive Strategies

Without considering the stages of change, our results show that COVID Pacman is effective overall and across the attitude, intention, self-efficacy, and knowledge change. However, considering the stages of change, show that the strategies vary in their effectiveness depending on the stages of change of an individual under consideration. Self-monitoring and competition/comparison are more effective for people in the later stage of the behaviour change but not for those in the early stage of behaviour change for all the four measures: attitude, intention, self-efficacy, and knowledge, and the differences are significant (p <.0005). Similarly, reward and suggestions are more effective for people in the early stage of behaviour change but not for those in the later stage, for all the four measures: attitude, intention, self-efficacy, and knowledge, and the differences are significant (p <.0005). This may explain why many interventions based on one-size-fits-all approach record varying degrees of success, mixed results, and even failures sometimes [88, 113]. Given these differences in individuals' stages of change, when they are randomly exposed to a generic intervention, the effectiveness of the strategies adopted in the intervention design may be equivocal. There is a high possibility of mixed findings since the strategies may work well for some people and not work for others depending on their stages of change. Hence, it is essential to use the appropriate persuasive strategy for addressing the need of people at different stages of change, and hence effectively motivate behaviour change among them.

6.2 Employing Competition and Reward in Behaviour Change Interventions

Many discussions have occurred within gamified, game for change, and persuasive games community on the use of competition and reward to motivate behaviour change. Research has suggested the tendency of the competition strategy to discourage some people who are not competitive and people who are not skilled enough in a particular task [118, 132]. Similarly, it has been argued that reward could undermine the main purpose of behaviour change and has the potential of redirecting the intention of a particular activity [19, 35, 68]. Our study shows that rewards and competition can be effective strategies for motivating behaviour change if well matched to the individual's stage of change. Competition/comparison worked well for people in the later stage of behaviour change but not those in the early stage. This is understandable, since people at the early stage deal with many uncertainties and are ambivalent, competition/comparison may possibly put a lot of pressure on them that may discourage them and make them drop off from using the intervention. On the other hand, those at the later stage are already in the process of behaviour change and just need some extra nudge to keep them motivated and active, hence competition is ideal for them. Reward works well for those at the early stage because it encourages and incentives them for every little effort without adding much pressure. Therefore, it is crucial to tailor persuasive interventions to match people's stages of change.

6.3 Tailoring Behaviour Change Games by Adapting only the Strategies Employed

Often designers apply the one-size-fits-all approach as opposed to tailoring their interventions to individuals' characteristics. The most common concern is the costs along with the level of work required in designing and adapting the game to different stages of change. The success of the two versions of the COVID Pacman shows that game designers do not have to design each game version from scratch to meet the needs of individuals at different stages of change. Tailoring can easily be achieved by employing appropriate strategies according to an individuals' stages of change. Designers of behaviour change games can easily adapt only the strategies without making significant changes to the game, as exemplified in the design of the two versions of COVID Pacman. Previous research has shown that considering stages of change in tailoring persuasive systems can have significant impact in the perception of the persuasive strategies based on survey study [11]. Our work extends these findings to the contest of game by implementing the strategies in actual game and conducting a user study. We show that tailoring the COVID Pacman by

employing appropriate persuasive strategies that matches an individual's stage of change can positively impact the motivation and promote behaviour change. Moreover, our findings could guide designers in deciding the appropriate strategies to employ when designing games targeting different stages of change. We show that self-monitoring and competition work well for people in the later stage of behaviour change while reward and suggestion work well for those in the early stage. Therefore, we can conclude that there is a **need for tailoring the interventions based on individuals' stage of change**.

6.4 COVID Pacman - Positive Play Experience

The results of the evaluation for all the variables measured under player experience showed that the players experienced the game positively with respect to interest and enjoyment, perceived competence, effort and importance, value and usefulness. Only one of these variables i.e, pressure and tension showed a negative score as shown in Figure 6.1. A possible reason why pressure and tension showed a negative score is because COVID Pacman gameplay is very easy, therefore it causes little or no tension or pressure on players.

Table 6.1: COVID Pacman overall Means and Standard Deviation of all variables under play experience

Interest & Enjoyment		**Perceived Competence**		**Effort & Importance**		**Pressure & Tension**		**Value & Usefulness**	
M	SD	M	SD	M	SD	M	SD	M	SD
5.06	1.43	5.48	1.34	5.28	1.38	2.72	1.26	5.55	1.39

Since 4 out of 5 player experience variables tested came out with positive scores, we can conclude that the player experience of COVID Pacman was very positive.

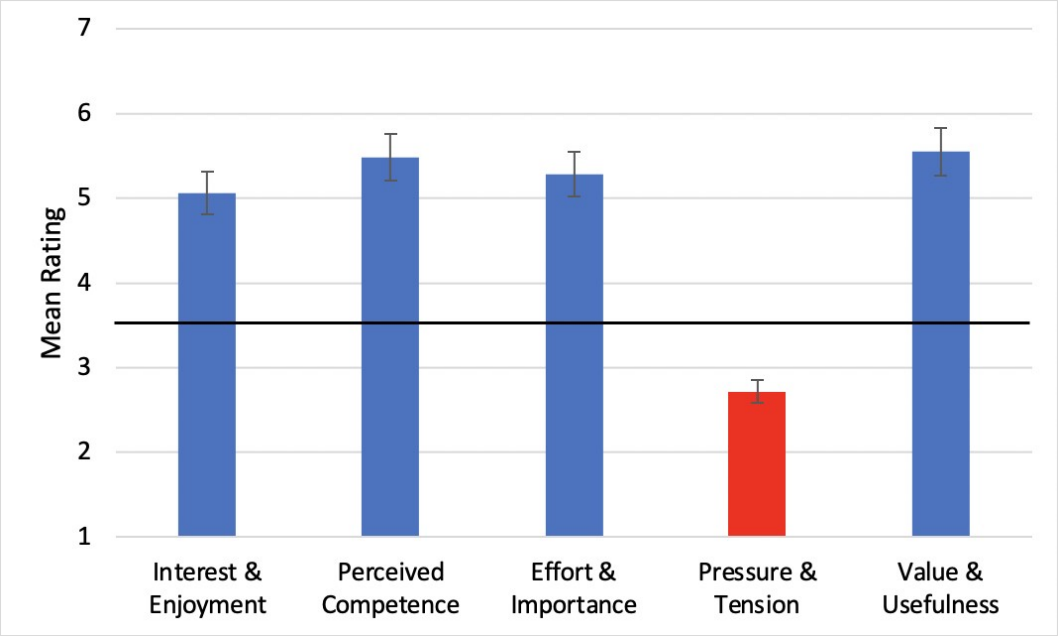


Figure 6.1: Bar graph for the mean of the IMI sub scales for COVID Pacman. Error bars represent 95% confidence interval.

As seen in the bar graph (Figure 6.1), the best attributes of the game as perceived by the players is value and usefulness attribute followed by perceived competence. High score for values and usefulness implies that the players found the game very useful in their daily life for adopting COVID-19 precautionary measures. Also, high perceived competence implies that the participants believed in their capabilities and ability to adopt to COVID-19 precautionary measures in real life after the intervention. According to a research, adults who have a high perceived competence are more likely to enjoy the activities they are involved in. This on the long run implies that COVID Pacman will likely be played for a longer time since players enjoyed it.

Interest and enjoyment are an important attribute required for a game to be successful. If the players are not interested in a game and they do not get a level of enjoyment from it, the game can't be described as successful because enjoyment and fun are some of the main motives why people play the games. COVID Pacman showed a significantly high score in interest and enjoyment which implies that COVID Pacman was really enjoyed by the players. The fact that the game experience was enjoyed by the players implies that there is a chance that players play this game again for a longer period of time. Long-time engagement is an important factor for a

persuasive game that would promote behaviour change over a long period of time. We were cautious to conclude about long-term engagement from this research as the game as only played for 10 days, which is not long enough to make such a conclusion. However, we believe that the players will engage with the game longer since they enjoyed playing it.

Our findings also proved that players found the game useful. This is really important as one of the major challenges faced by the persuasive game researchers is how to balance the fun aspect of the game and the usefulness with respect to motivating the desired behaviour change. Many games easily achieve the fun element but the not the value and usefulness. The results of the COVID Pacman evaluation shows that game successfully achieved both the fun (interest and enjoyment) and the usefulness (value and usefulness) element. We achieved this balance by using the iterative user design process in the development of COVID Pacman. This allowed us to work with potential users, iteratively design, evaluate, and refine the game to achieve the final design.

Our results are equally supported with high scores on perceived importance. It often happens that player will abandon the game when they don't see any importance of playing that game. If the game does not seem to have any value to them or if it has no purpose, some players might abandon the game. COVID Pacman showed the high score on importance, value and usefulness. This shows that players saw the importance of the game in their daily lives of adhering to COVID-19 precautionary measures. It also means that it adds a lot of value to their individual lives. This is very important finding, as the players need to understand the importance and value of adopting COVID-19 precautionary measures in their daily lives.

One of the other reasons why players generally stop playing the game is because it is frustrating to play – due to excessively difficult game challenge, bad controls, or poor graphical representation. This would make the players feel incompetent to play the game. COVID Pacman showed the high score in perceived competence. This implies that the player of the game feels very competent while playing the game. In other words, players feel confident in their ability to understand and handle the different situations and challenges in the game. This suggests that game was not too hard, and the players felt confident in their ability to follow these measures in their daily life.

The only variable that showed a score below the midpoint is the pressure and tension subscale. This is also important element in our findings as this directly affects how long the game would be

played. Every ideal game has to pose some level of difficulty because if it is too easy, players may easily get bored of the game in the long run. COVID Pacman showed a low level of pressure and tension. We intentionally favoured interest and enjoyment over pressure and tension because we wanted majority of the players to finish all the game levels and hence acquire the intended knowledge that would lead to change in attitude, intention and self-efficacy. This shows that game was successful in motivating the desired behaviour change among the participants.

6.5 Perceived Persuasiveness of COVID Pacman

Persuasiveness can be described as the ability of the intervention to cause a change in the target behaviour to the desired behaviour [112]. The higher the persuasiveness of the intervention the, the more is the likelihood of the intervention to cause the desired behaviour change. From our results, we can conclude that the COVID Pacman was perceived to be persuasive among the participants. This shows that our game has a strong potential of being persuasive. This also validates that the combination of persuasive strategies we employed in different versions of the game were effective overall.

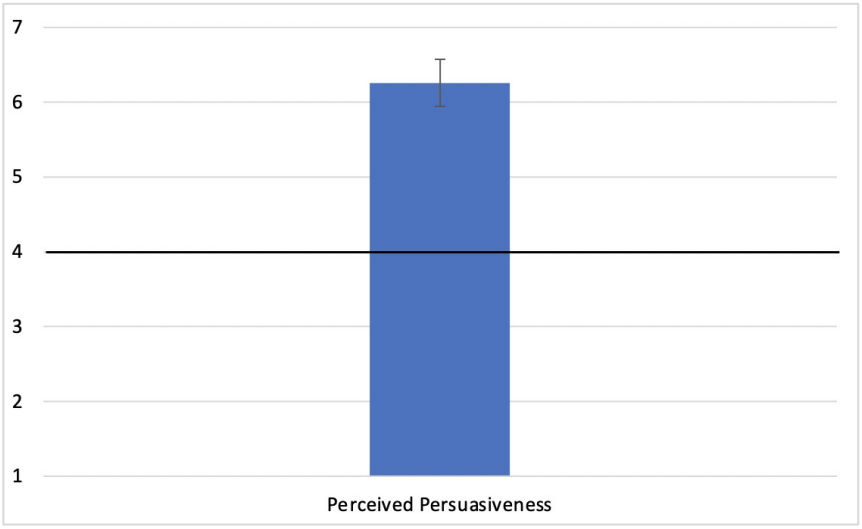


Figure 6.2: Persuasiveness score of COVID Pacman over the 4.0 normal score. Error bar represent the 95% confidence interval.

7 CHAPTER 7 CONCLUSION

In this chapter, we summarized the thesis and highlights the limitations, contributions, and suggested potential directions for future work.

7.1 Limitations

The main limitation of this research is self-reporting. Although, we instructed the participants, in the consent form, to answer the questions sincerely and to make their answers a representation of individual state of mind, it is a common belief that human perception is not always perfect, and bias would most likely be present. Although we can't control the bias factor, but we made sure that we collected their baseline (pre-test) attitude, intention, self-efficacy, knowledge towards adopting COVID-19 precautionary measures. This baseline was further used to compare the actual change (post-test) in attitude, intention, self-efficacy, and knowledge to measure the desired beahviour change among participants.

Another limitation in our research is that we made COVID Pacman only for desktop devices. Although our background research and our data analysis show that there approximately same number participants who play games on desktop and mobile phone. This means that this intervention does not cater for the participants who like to play games on their phones. Future version of the game will be designed for both desktop and mobile devices to cater for wider group of audiences.

Some players also identified the fact that the game was too easy because of only 3 levels designed in the game. This fact was also evident in the low score for tension and pressure under the play experience data collected. The difficulty of the game was made equally for all player for the purpose of the study. The next version of the game would have an option to choose between three levels of difficulty: easy, medium and hard.

7.2 Study Summary

In our pre-test post-test design study of 127 participants, with 57% males and 43% females, we effectively examined if different versions of COVID Pacman motivated individuals at different stages of change by measuring the change in their attitude, intention, self-efficacy, and knowledge towards adopting COVID-19 precautionary measures. Further we also, investigated the motivational appeal of COVD Pacman. Finally, we examined our participants' overall experience

from playing the game and also the perceived persuasiveness of COVID Pacman with respect to motivating change in adoption of COVID-19 precautionary measures.

The findings are summarized in table 7.1 below:

Tested Variables	**Outcome**
Efficacy of the game to promote behaviour change (attitude, intention, self-efficacy, and knowledge)	Positive change in attitude, intention, self-efficacy, and knowledge of the participants for people who played the tailored version of the game as compared to non-tailored version
Motivational Appeal	Highly Effective overall as well as across four dimensions (attention, relevance, confidence, and satisfaction) for participants who played tailored version as compared to non-tailored version
Perceived Persuasiveness	Highly Persuasive
Play Experience	Positive Play Experience for people who played tailored version of the game as compared to non-tailored version

Apart from the outcome above, our study findings also revealed that participants showed positive change in intention, attitude self-efficacy, and knowledge when they interacted with tailored versions as compared to non-tailored versions. In addition to that, the motivational appeal of the game was high for participants who played tailored version instead of non-tailored. Finally, participants who played tailored version of the game experienced positive play experience as compared to participants who played non-tailored version. This concludes that there is a need for tailoring the interventions based on individuals' stage of change.

7.3 Future Work

In the future, we plan to run a more comprehensive study with a bigger sample size, for a longer duration. The duration of the study would be 3 months or more. There would be minimum three points of data collection about the behaviour of the participants for this study. One time point at the beginning (baseline), one time point immediately at the end, and the third time point one month or more after the study. This would help to keep track of participants' progress and the effectiveness of the game with respect to motivating and sustaining behaviour change. Although our study showed some interesting and significant findings, it also opens up many research areas for other researchers in this domain. We measured motivation, which is a precursor to actual behaviour change, future work should investigate if the increase in motivation translates to actual

behaviour. We can achieve this by our plan of running the comprehensive study with longer duration. We will also explore if our result generalizes to other domains e.g., physical activity, healthy eating, disease management, and sustainable environment.

7.4 Conclusion

This thesis contributes to an important research field of persuasive technology within the Human Computer Interaction domain by developing the tailored persuasive interventions in the form of different versions of the game for individuals at different stages of change. It demonstrates how persuasive games can be designed and tailored to promote the adoption of COVID-19 precautionary measures. Specifically, we designed two versions of COVID pacman with different persuasive strategies in each, targeting different individuals according to their stages of change for motivating them to adhere to COVID-19 precautionary measures. The results of 10-day evaluation answered our overarching research question: "*Is COVID Pacman effective in motivating a positive change in the adoption of COVID-19 precautionary measures?"*.

Both games versions targeted the same goal of creating awareness and motivating the adoption of COVID-19 precautionary measures. We conducted a user evaluation of 127 participants. The results show that one size does not fit all – it effectively demonstrated that tailoring the COVID Pacman based on individual's stage of change by selecting the appropriate persuasive strategy can result in positive change in attitude, intention, self-efficacy, and knowledge compared to the untailored game version. Also, playing the tailored game version resulted high motivational appeal (attention, relevance, confidence, and satisfaction) as compared to non-tailored game. Finally, our findings also show that players found the game to be highly persuasive and also had a positive play experience from playing the game (specifically for those who played the tailored version of the game) as shown by their feedback comments in qualitative data analysis as well as the statistically significant scores in interest/enjoyment, perceived competence, value/usefulness, effort/importance, pressure/tension.

7.5 Publications

We successfully designed and developed COVID Pacman that can persuade people to follow COVID-19 precautionary measures. This game was designed in two versions (using different persuasive strategies in each) tailored to individual's stages of change. We successfully conducted an evaluation with 127 participants and showed that COVID Pacman promotes a positive change

in attitude, intention, self-efficacy, and knowledge of individuals with respect to COVID-19 precautionary measures. We also showed that COVID Pacman has a significantly high motivational appeal to effectively motivate individuals to adhere to COVID-19 precautionary measures. Moreover, our results also showed that participants who played tailored version of the game were significantly motivated as compared to participants who played non-tailored version of the game. Our findings also showed that players had positive play experience after playing the tailored versions of the COVID Pacman as compared to non-tailored. Finally, our results also show that the game is perceived to be highly persuasive with respect to its ability to promote adoption of COVID-19 precautionary measures. Based on our results, we can therefore say that there is need of tailoring persuasive games according to individuals' stages of change.

7.5.1 Publications from this Thesis

So far, this research has led to **two publications** and additional **two papers submitted** and waiting for acceptance notification.

Paper Title	**Status**	**Conference**
COVID Pacman – A Persuasive Game to promote the adoption of COVID-19 precautionary measures	**Accepted**	UMAP - 2021
Persuasiveness of a Game to Promote the Adoption of COVID-19 Precautionary Measures and the Moderating Effect of Gender	**Accepted**	Adaptive and Personalized Persuasive Technology Workshop, 2021
Age and the persuasiveness of the game to promote the adoption of COVID-19 precautionary measures	Submitted	IEEE SEGAH, 2021
Design and Evaluation of COVID Pacman – A Persuasive Game to Promote the Adoption of COVID-19 Precautionary Measures Tailored to the Stages of Change	Submitted	CSCW, 2021

7.5.2 Other publications during my Master's Degree

So far, I have **published four papers** and additional **one paper is submitted** and waiting for acceptance notification.

Paper Title	Status	Conference
Tailoring Persuasive and Behaviour Change Systems Based on Stages of Change and Motivation	**Accepted**	CHI - 2021
Health, Psychosocial, and Social Issues Emanating From the COVID-19 Pandemic Based on Social Media Comments: Text Mining and Thematic Analysis Approach	**Accepted**	JMIR Medical Informatics 2021
A Systematic Review of Persuasive Strategies in Stress Management Apps	**Accepted**	BCSS (Behaviour Change Support Systems) 2020
A Tri-Hybrid Brain-Computer Interface for Neuro-Information Systems	**Accepted**	Neuro IS (Information Systems) 2020
Sleep Fit: A Persuasive Mobile App for Improving Sleep Habits Among Young Adults	Submitted	IEEE SEGAH, 2021

BIBLIOGRAPHY

[1] Abdessettar, S. et al. 2016. Persuasive Technologies for Efficient Adaptable Self-Education Kids Smart Mobile School Project. *The Eighth International Conference on Mobile, Hybrid, and On-line Learning* (2016).

[2] Adaptive Persuasive Games for Wellbeing — The University of Aberdeen: *https://abdn.pure.elsevier.com/en/publications/adaptive-persuasive-games-for-wellbeing*. Accessed: 2021-01-21.

[3] Aiolli, F. et al. 2014. ClimbTheWorld: Real-time stairstep counting to increase physical activity. *MobiQuitous 2014 - 11th International Conference on Mobile and Ubiquitous Systems: Computing, Networking and Services* (2014), 218–227.

[4] Ajzen, I. 2011. The theory of planned behaviour: Reactions and reflections. *Psychology & Health*. 26, 9 (Sep. 2011), 1113–1127. DOI:https://doi.org/10.1080/08870446.2011.613995.

[5] Al-Tawfiq, J.A. and Pittet, D. 2013. Improving Hand Hygiene Compliance in Healthcare Settings Using Behavior Change Theories: Reflections. *Teaching and Learning in Medicine*. 25, 4 (Oct. 2013), 374–382. DOI:https://doi.org/10.1080/10401334.2013.827575.

[6] Alhabash, S. and Wise, K. 2012. *PeaceMaker: Changing Students' Attitudes Toward Palestinians and Israelis Through Video Game Play*. Quandt.

[7] Almonani, E. et al. 2014. Mobile game approach to prevent childhood obesity using persuasive technology. *2014 International Conference on Computer and Information Sciences, ICCOINS 2014 - A Conference of World Engineering, Science and Technology Congress, ESTCON 2014 - Proceedings* (Jul. 2014).

[8] Almutari, N. and Orji, R. 2019. How effective are social influence strategies in persuasive apps for promoting physical activity? A systematic review. *ACM UMAP 2019 Adjunct - Adjunct Publication of the 27th Conference on User Modeling, Adaptation and Personalization*. Adappt (2019), 167–172. DOI:https://doi.org/10.1145/3314183.3323855.

[9] Alqahtani, F., Meier S., and O.R. (2021). 2021. Personality-based Approach for Tailoring Persuasive Mental Health Applications. *User Modeling and User-Adapted Interaction*. (2021).

[10] Alslaity, A. and Tran, T. 2020. On the Impact of the Application Domain on Users' Susceptibility to the Six Weapons of Influence. *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)* (Apr. 2020), 3–15.

[11] Altmeyer, M. et al. Combining Behavior Change Intentions and User Types to Select Suitable Gamification Elements for Persuasive Fitness Systems. DOI:https://doi.org/10.1007/978-3-030-17287-9_27.

[12] Arteaga, S.M. et al. 2010. Mobile system to motivate teenagers' physical activity. *Proceedings of IDC2010: The 9th International Conference on Interaction Design and Children* (New York, New York, USA, 2010), 1–10.

[13] Avert Org: *https://www.avert.org/take-our-covid-19-quiz*.

[14] Bang, M. et al. 2009. Persuasive design of a mobile energy conservation game with direct feedback and social cues. *Breaking New Ground: Innovation in Games, Play, Practice and Theory - Proceedings of DiGRA 2009*. January (2009).

[15] Baranowski, T. et al. 2003. Squire's Quest!: Dietary outcome evaluation of a multimedia game. *American Journal of Preventive Medicine*. 24, 1 (Jan. 2003), 52–61. DOI:https://doi.org/10.1016/S0749-3797(02)00570-6.

[16] Baskerville, N.B. et al. Crush the Crave: Development and Formative Evaluation of a Smartphone App for Smoking Cessation. DOI:https://doi.org/10.2196/mhealth.9011.

[17] Bassett-Gunter, R. et al. 2017. Motivating parent support for physical activity: The role of framed persuasive messages. *Health Education Research*. 32, 5 (2017), 412–422. DOI:https://doi.org/10.1093/her/cyx059.

[18] Berkovsky, S. et al. 2010. Physical activity motivating games: Virtual rewards for real activity. *Conference on Human Factors in Computing Systems - Proceedings* (New York, New York, USA, 2010), 243–252.

[19] Birk, M. V. et al. 2016. The motivational push of games: The interplay of intrinsic motivation and external rewards in games for training. *CHI PLAY 2016 - Proceedings of the 2016 Annual Symposium on Computer-Human Interaction in Play* (New York, NY, USA, Oct. 2016), 291–303.

[20] Brown, S.J. et al. 1997. Educational video game for juvenile diabetes: Results of a controlled trial. *Medical Informatics*. 22, 1 (1997), 77–89.

DOI:https://doi.org/10.3109/14639239709089835.

[21] Burke, L.E. et al. 2009. Experiences of self-monitoring: Successes and struggles during treatment for weight loss. *Qualitative Health Research*. 19, 6 (2009), 815–828. DOI:https://doi.org/10.1177/1049732309335395.

[22] Busch, M. et al. 2016. Player type models - Towards empirical validation. *Conference on Human Factors in Computing Systems - Proceedings* (New York, NY, USA, May 2016), 1835–1841.

[23] Buttussi, F. et al. 2013. Evaluation of a 3D serious game for advanced life support retraining. *International Journal of Medical Informatics*. 82, 9 (Sep. 2013), 798–809. DOI:https://doi.org/10.1016/j.ijmedinf.2013.05.007.

[24] Cadamuro, A. and Visch, V. 2013. 'What Remains?': A Persuasive Story Telling Game. *Games for Health*. Springer Fachmedien Wiesbaden. 153–160.

[25] Centers of Disease Control and Prevention (CDC): 2021. *https://www.cdc.gov/*.

[26] Chen, Y.X. et al. 2014. Opportunities for persuasive technology to motivate heavy computer users for stretching exercise. *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)* (2014), 25–30.

[27] Chen, Y.X. et al. 2014. Opportunities for persuasive technology to motivate heavy computer users for stretching exercise. *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)* (2014), 25–30.

[28] Chiou, J.-S. *The Effects of Attitude, Subjective Norm, and Perceived Behavioral Control on Consumers' Purchase Intentions: The Moderating Effects of Product Knowledge and Attention to Social Comparison Information*.

[29] Chittaro, L. and Sioni, R. 2012. Turning the classic snake mobile game into a location-based exergame that encourages walking. *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)* (2012), 43–54.

[30] Chiu, M.C. et al. 2009. Playful bottle: A mobile social persuasion system to motivate healthy water intake. *ACM International Conference Proceeding Series* (New York, NY, USA, Sep. 2009), 185–194.

[31] Cialdini, R.B. 2001. *Harnessing the Science of Persuasion*.

[32] Ciocarlan, A. et al. 2018. Kindness is contagious: Study into exploring engagement and adapting persuasive games for wellbeing. *UMAP 2018 - Proceedings of the 26th Conference on User Modeling, Adaptation and Personalization* (Jul. 2018), 311–319.

[33] Clark, C. et al. 2020. Predictors of COVID-19 voluntary compliance behaviors: An international investigation. *Global Transitions*. 2, (2020), 76–82. DOI:https://doi.org/10.1016/j.glt.2020.06.003.

[34] Coles, C.D. et al. 2007. Games that "work": Using computer games to teach alcohol-affected children about fire and street safety. *Research in Developmental Disabilities*. 28, 5 (Oct. 2007), 518–530. DOI:https://doi.org/10.1016/j.ridd.2006.07.001.

[35] Colineau, N. and Paris, C. 2010. Can Beneficial Habits Be Induced through Reflection? Springer.

[36] COVID-19 Map: .

[37] COVID Pacman Demo: *https://www.youtube.com/watch?v=iZAxP-xxdcY&ab_channel=DineshMulchandani*.

[38] Damanhoori, F. et al. E-mentoring System Development using ARCS Motivational Strategies. *International Journal of Smart Home*. 6, 3, 83–90.

[39] Davis, S.B. et al. 2006. 'Ere Be Dragons: Heartfelt gaming. *Digital Creativity*. 17, 3 (2006), 157–162. DOI:https://doi.org/10.1080/14626260600882430.

[40] Depigny, S. and Michelin, Y. 2007. SHRUB BATTLE: Understanding the making of landscape. *Simulation & Gaming*. 38, 2 (Jun. 2007), 263–277. DOI:https://doi.org/10.1177/1046878107300666.

[41] Derbali, L. et al. 2012. Assessment of Learners' Motivation during Interactions with Serious Games: A Study of Some Motivational Strategies in Food-Force. 2012, (2012), 15. DOI:https://doi.org/10.1155/2012/624538.

[42] Derbali, L. and Frasson, C. 2011. Physiological evaluation of attention getting strategies during serious game play. *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)* (2011), 447–449.

[43] Derbali, L. and Frasson, C. 2010. Players' motivation and EEG waves patterns in a serious game environment. *Lecture Notes in Computer Science (including subseries Lecture Notes*

in Artificial Intelligence and Lecture Notes in Bioinformatics). 6095 LNCS, PART 2 (2010), 297–299. DOI:https://doi.org/10.1007/978-3-642-13437-1_50.

[44] Designing a Motivated Tangible Multimedia System for Preschoolers: *https://publications.waset.org/10006533/designing-a-motivated-tangible-multimedia-system-for-preschoolers*. Accessed: 2021-01-22.

[45] Dickinson, A. et al. 2015. UKKO: Enriching persuasive location based games with environmental sensor data. *CHI PLAY 2015 - Proceedings of the 2015 Annual Symposium on Computer-Human Interaction in Play* (New York, NY, USA, Oct. 2015), 493–498.

[46] Ding, Y. et al. 2020. Risk perception of coronavirus disease 2019 (COVID-19) and its related factors among college students in China during quarantine. *PLoS ONE*. 15, 8 August (2020), 1–13. DOI:https://doi.org/10.1371/journal.pone.0237626.

[47] Dominic, D. et al. 2013. Promoting Physical Activity through Persuasive Technology. *International Journal of Inventive Engineering and Sciences (IJIES)*. 2, 1 (2013), 16–22.

[48] Dreamlo: .

[49] Effect of Computer-Based Video Games on Children: An Experimental Study on JSTOR: *https://www.jstor.org/stable/jeductechsoci.12.2.1?seq=1#metadata_info_tab_contents*. Accessed: 2021-03-23.

[50] Enah, C. et al. 2015. Qualitative Evaluation of the Relevance and Acceptability of a Web-Based HIV Prevention Game for Rural Adolescents. *Journal of Pediatric Nursing*. 30, 2 (Mar. 2015), 321–328. DOI:https://doi.org/10.1016/j.pedn.2014.09.004.

[51] Epidemic Game Sounds: .

[52] Evers, K.E. et al. 2006. A randomized clinical trial of a population- and transtheoretical model-based stress-management intervention. *Health Psychology*. 25, 4 (Jul. 2006), 521–529. DOI:https://doi.org/10.1037/0278-6133.25.4.521.

[53] Evers, K.E. et al. 2012. Results of a Transtheoretical Model-Based Alcohol, Tobacco and Other Drug Intervention in Middle Schools. *Addictive Behaviors*. 37, 9 (Sep. 2012), 1009–1018. DOI:https://doi.org/10.1016/j.addbeh.2012.04.008.

[54] Felwah Alqahtani, Sandra Meier, R.O. 2021. Personality-based Approach for Tailoring Persuasive Mental Health Applications, User Modeling and User-Adapted Interaction. *User Modeling and User-Adapted Interaction* (2021).

[55] Ferron, M. et al. *Play&Go, an Urban Game Promoting Behaviour Change for Sustainable*

Mobility.

[56] Ferron, M. et al. Transtheoretical Model for Designing Technologies Supporting an Active Lifestyle. DOI:https://doi.org/10.1145/2499149.2499158.

[57] Ferron, M. and Massa, P. 2013. Transtheoretical model for designing technologies supporting an active lifestyle. *ACM International Conference Proceeding Series* (New York, New York, USA, 2013), 1–8.

[58] Fiellin, L.E. et al. 2016. The design and implementation of a randomized controlled trial of a risk reduction and human immunodeficiency virus prevention videogame intervention in minority adolescents: PlayForward: Elm City Stories. *Clinical Trials*. 13, 4 (Aug. 2016), 400–408. DOI:https://doi.org/10.1177/1740774516637871.

[59] Fogg, B. 2009. A behavior model for persuasive design. *Proceedings of the 4th International Conference on Persuasive Technology* (New York, New York, USA, 2009), 7.

[60] Fogg, B.J. 2009. Creating persuasive technologies: An eight-step design process. *ACM International Conference Proceeding Series* (New York, New York, USA, 2009), 1.

[61] Fogg, B.J. and Fogg, G.E. 2003. *Persuasive Technology: Using Computers to Change What We Think and Do*. Morgan Kaufmann.

[62] Fujiki, Y. et al. 2008. NEAT-o-Games: Blending physical activity and fun in the daily routine. *Computers in Entertainment*. 6, 2 (Jul. 2008), 1–22. DOI:https://doi.org/10.1145/1371216.1371224.

[63] Fujiki, Y. et al. 2008. NEAT-o-Games: Blending physical activity and fun in the daily routine. *Computers in Entertainment*. 6, 2 (Jul. 2008), 1–22. DOI:https://doi.org/10.1145/1371216.1371224.

[64] Gamberini, L. et al. 2011. Saving is fun: Designing a persuasive game for power conservation. *ACM International Conference Proceeding Series* (New York, New York, USA, 2011), 1.

[65] Gerling, K.M. et al. 2014. The effects of embodied persuasive games on player attitudes toward people using wheelchairs. *Conference on Human Factors in Computing Systems - Proceedings* (New York, NY, USA, Apr. 2014), 3413–3422.

[66] Gerling, K.M. et al. 2014. The Effects of Embodied Persuasive Games on Player Attitudes Toward People Using Wheelchairs. (2014).

DOI:https://doi.org/10.1145/2556288.2556962.

[67] Global Stats Counter: 2021. *https://gs.statcounter.com/platform-market-share/desktop-mobile-tablet/north-america*.

[68] Gneezy, U. and Rustichini, A. 2000. Pay enough or don't pay at all. *Quarterly Journal of Economics*. 115, 3 (2000), 791–810. DOI:https://doi.org/10.1162/003355300554917.

[69] Gopalan, V. et al. 2017. A review of the motivation theories in learning. *AIP Conference Proceedings* (Oct. 2017), 020043.

[70] Gray et al. 2020. The Sugargotchi: An Embodied Digital Pet to Raise Children's Awareness of their Dental Health and Free Sugar Consumption. (2020). DOI:https://doi.org/10.1145/3383668.3419874.

[71] Grimes, A. et al. 2010. Let's play! Mobile health games for adults. *UbiComp'10 - Proceedings of the 2010 ACM Conference on Ubiquitous Computing* (New York, NY, USA, Sep. 2010), 241–250.

[72] Gustafsson, A. et al. 2009. Evaluation of a pervasive game for domestic energy engagement among teenagers. *Computers in Entertainment*. 7, 4 (Dec. 2009), 1–19. DOI:https://doi.org/10.1145/1658866.1658873.

[73] Hamari, J. et al. 2014. Do persuasive technologies persuade? - A review of empirical studies. *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)* (2014), 118–136.

[74] Hamari, J. et al. 2014. Does gamification work? - A literature review of empirical studies on gamification. *Proceedings of the Annual Hawaii International Conference on System Sciences* (2014), 3025–3034.

[75] He, H.A. et al. 2010. One size does not fit all: Applying the transtheoretical model to energy feedback technology design. *Conference on Human Factors in Computing Systems - Proceedings* (New York, New York, USA, 2010), 927–936.

[76] Hermans, R.C.J. et al. 2018. Feed the Alien! the Effects of a Nutrition Instruction Game on Children's Nutritional Knowledge and Food Intake. *Games for Health Journal*. 7, 3 (Jun. 2018), 164–174. DOI:https://doi.org/10.1089/g4h.2017.0055.

[77] Horwath, C.C. 1999. Applying the transtheoretical model to eating behaviour change: challenges and opportunities. *Nutrition Research Reviews*. 12, 2 (Dec. 1999), 281–317. DOI:https://doi.org/10.1079/095442299108728965.

[78] Höysniemi, J. 2006. International survey on the dance dance revolution game. *Computers in Entertainment*. 4, 2 (Apr. 2006), 8. DOI:https://doi.org/10.1145/1129006.1129019.

[79] Hsu, A. et al. Persuasive Technology for Overcoming Food Cravings and Improving Snack Choices. DOI:https://doi.org/10.1145/2556288.2557099.

[80] Huss, K. et al. 2003. Computer game for inner-city children does not improve asthma outcomes. *Journal of Pediatric Health Care*. 17, 2 (2003), 72–78. DOI:https://doi.org/10.1067/mph.2003.28.

[81] Huss, K. et al. 2003. Computer game for inner-city children does not improve asthma outcomes. *Journal of Pediatric Health Care*. 17, 2 (2003), 72–78. DOI:https://doi.org/10.1067/mph.2003.28.

[82] Interactive video games for health promotion: Effects on knowledge, self-efficacy, social support, and health. - PsycNET: *https://psycnet.apa.org/record/1997-08592-006*. Accessed: 2021-03-13.

[83] Ito, C. et al. 2013. Preliminary evaluation of a serious game for the dissemination and public awareness on preschool children's oral health. *Studies in Health Technology and Informatics* (2013), 1034.

[84] Jacob, M. et al. *Motivating children to learn effectively: exploring the value of intrinsic integration in educational games*.

[85] Jensen, K.L. et al. 2010. Studying PH.A.N.T.O.M. in the wild: A pervasive persuasive game for daily physical activity. *ACM International Conference Proceeding Series* (New York, New York, USA, 2010), 17–20.

[86] Kadomura, A. et al. 2013. Sensing fork and persuasive game for improving eating behavior. *UbiComp 2013 Adjunct - Adjunct Publication of the 2013 ACM Conference on Ubiquitous Computing* (New York, NY, USA, Sep. 2013), 71–74.

[87] Kaipainen, K. et al. 2012. Mindless eating challenge: Retention, weight outcomes, and barriers for changes in a public web-based healthy eating and weight loss program. *Journal of Medical Internet Research*. 14, 6 (2012). DOI:https://doi.org/10.2196/jmir.2218.

[88] Kaptein, M. et al. 2012. Adaptive persuasive systems: A study of tailored persuasive text messages to reduce snacking. *ACM Transactions on Interactive Intelligent Systems*. Association for Computing Machinery.

[89] Kato, P.M. et al. 2008. A video game improves behavioral outcomes in adolescents and young adults with cancer: A randomized trial. *Pediatrics*. 122, 2 (Aug. 2008). DOI:https://doi.org/10.1542/peds.2007-3134.

[90] Kato, P.M. 2010. Video Games in Health Care: Closing the Gap. (2010). DOI:https://doi.org/10.1037/a0019441.

[91] Keller, J. M., & Reigeluth, C.M. (1983). 1983. Motivational design of instruction. Instructional design theories and models: An overview of their current status. (1983), 383–434.

[92] Keller, J.M. 1987. Development and use of the ARCS model of instructional design. *Journal of Instructional Development*. 10, 3 (Sep. 1987), 2–10. DOI:https://doi.org/10.1007/BF02905780.

[93] Khaled, R. et al. 2008. A Qualitative Study of Culture and Persuasion in a Smoking Cessation Game. *Persuasive Technology*. Springer Berlin Heidelberg. 224–236.

[94] Khaled, R. et al. 2009. Game design strategies for collectivist persuasion. *Proceedings of the 2009 ACM SIGGRAPH Symposium on Video Games, Sandbox '09* (New York, New York, USA, 2009), 31–38.

[95] Lee, J.E. et al. 2017. Development of tailored nutrition information messages based on the transtheoretical model for smartphone application of an obesity prevention and management program for elementary-school students. *Nutrition Research and Practice*. 11, 3 (Jun. 2017), 247–256. DOI:https://doi.org/10.4162/nrp.2017.11.3.247.

[96] Lin, J.J. et al. 2006. Fish'n'Steps: Encouraging physical activity with an interactive computer game. *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)* (2006), 261–278.

[97] Lin, T.-Y. et al. *A Persuasive Game to Encourage Healthy Dietary Behaviors of Kindergarten Children*.

[98] Luz, S. et al. 2016. Using a serious game to promote community-based awareness and prevention of neglected tropical diseases. *Entertainment Computing*. 15, (Jun. 2016), 43–55. DOI:https://doi.org/10.1016/j.entcom.2015.11.001.

[99] Madeira, R.N. et al. 2011. LEY! Persuasive pervasive gaming on domestic energy consumption-awareness. *ACM International Conference Proceeding Series* (New York, New York, USA, 2011), 1.

[100] Mansour, A. et al. 2009. MunchCrunch: A game to learn healthy-eating heuristics. *Proceedings of IDC 2009 - The 8th International Conference on Interaction Design and Children* (New York, New York, USA, 2009), 166–169.

[101] Master's Paper | Taking Control of the Zombie Epidemic: Immunizing the Public through Infectious Disease Emergency Preparedness Public Health Entertainment | ID: z029p836w | Carolina Digital Repository: *https://cdr.lib.unc.edu/concern/masters_papers/z029p836w*. Accessed: 2021-05-27.

[102] Moore, J.B. et al. 2009. Childhood obesity study: A pilot study of the effect of the nutrition education program Color My Pyramid. *Journal of School Nursing*. 25, 3 (Jun. 2009), 230–239. DOI:https://doi.org/10.1177/1059840509333325.

[103] Munson, S.A. and Consolvo, S. 2012. Exploring goal-setting, rewards, self-monitoring, and sharing to motivate physical activity. *2012 6th International Conference on Pervasive Computing Technologies for Healthcare and Workshops, PervasiveHealth 2012* (2012), 25–32.

[104] Ndulue, C. et al. 2020. PHISHER CRUSH: A Mobile Persuasive Game for Promoting Online Security. *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)* (Apr. 2020), 223–233.

[105] Ndulue, C. 2019. Std pong 2.0 : an african-centric persuasive game for promoting risky sexual behaviour change. August (2019). DOI:https://doi.org/https://dalspace.library.dal.ca/handle/10222/76273.

[106] Ndulue, C. and Orji, R. 2018. STD PONG: Changing risky sexual behaviour in Africa through persuasive games. *ACM International Conference Proceeding Series* (New York, NY, USA, Dec. 2018), 134–138.

[107] Nkwo, M. and Orji, R. 2018. Persuasive Technology in African Context: Deconstructing Persuasive Techniques in an African Online Marketplace. 10, (2018). DOI:https://doi.org/10.1145/3283458.3283479.

[108] Nowak, G.J. et al. 2020. Using immersive virtual reality to improve the beliefs and intentions of influenza vaccine avoidant 18-to-49-year-olds: Considerations, effects, and lessons learned. *Vaccine*. 38, 5 (Jan. 2020), 1225–1233. DOI:https://doi.org/10.1016/j.vaccine.2019.11.009.

[109] Oinas-kukkonen, H. et al. 2009. Persuasive Systems Design: Key Issues, Process

Model,and System Features. 24, 1 (2009).

[110] De Oliveira, R. et al. 2010. MoviPill: Improving medication compliance for elders using a mobile persuasive social game. *UbiComp'10 - Proceedings of the 2010 ACM Conference on Ubiquitous Computing* (New York, NY, USA, Sep. 2010), 251–260.

[111] Opinio: .

[112] Orji, R. et al. 2019. Deconstructing persuasiveness of strategies in behaviour change systems using the ARCS model of motivation. *Behaviour and Information Technology*. 38, 4 (Apr. 2019), 319–335. DOI:https://doi.org/10.1080/0144929X.2018.1520302.

[113] Orji, R. et al. 2017. Improving the Efficacy of Games for Change Using. *ACM Transactions on Computer-Human Interaction*. 24, 5 (2017). DOI:https://doi.org/https://doi.org/10.1145/3119929.

[114] Orji, R. et al. 2013. LunchTime: A slow-casual game for long-term dietary behavior change. *Personal and Ubiquitous Computing*. 17, 6 (Aug. 2013), 1211–1221. DOI:https://doi.org/10.1007/s00779-012-0590-6.

[115] Orji, R. et al. 2014. Modeling the efficacy of persuasive strategies for different gamer types in serious games for health. *User Model User-Adap Inter*. 24, (2014), 453–498. DOI:https://doi.org/10.1007/s11257-014-9149-8.

[116] Orji, R. et al. 2014. Modeling the efficacy of persuasive strategies for different gamer types in serious games for health different gamer types in serious games for health. July (2014). DOI:https://doi.org/10.1007/s11257-014-9149-8.

[117] Orji, R. et al. 2013. Tailoring Persuasive Health Games to Gamer Type. *CHI 2013: Changing Perspectives* (Paris, France, 2013).

[118] Orji, R. et al. 2017. Towards personality-driven persuasive health games and gamified systems. *Conference on Human Factors in Computing Systems - Proceedings* (New York, NY, USA, May 2017), 1015–1027.

[119] Orji, R. et al. 2018. Tracking feels oppressive and 'punishy': Exploring the costs and benefits of self-monitoring for health and wellness. *Digital Health*. 4, (2018), 205520761879755. DOI:https://doi.org/10.1177/2055207618797554.

[120] Orji, R. and Moffatt, K. 2018. Persuasive technology for health and wellness: State-of-the-art and emerging trends. *Health Informatics Journal*. 24, 1 (2018), 66–91. DOI:https://doi.org/10.1177/1460458216650979.

[121] Orji, R. and Moffatt, K. 2018. Persuasive technology for health and wellness: State-of-the-art and emerging trends. *Health Informatics Journal*. 24, 1 (2018), 66–91. DOI:https://doi.org/10.1177/1460458216650979.

[122] Orji, R.O. 2014. *DESIGN FOR BEHAVIOUR CHANGE: A MODEL-DRIVEN APPROACH FOR TAILORING PERSUASIVE TECHNOLOGIES*. University of Saskatchewan (https://harvest.usask.ca/handle/10388/ETD-2014-06-1555).

[123] Oyebode, O., Ndulue, C., Mulchandani, D., Adib, A., Alhasani, M.,and Orji, R 2021. Tailoring Persuasive and Behaviour Change Systems Based on Stages of Change and Motivation. *Proceedings of the CHI Conference on Human Factors in Computing Systems - CHI2021* (2021).

[124] Oyebode, O. 2020. A Persuasive Mobile Game for Reducing Sedentary Behaviour and Promoting Physical Activity. *Persuasive 2020, Adjunct proceedings of the 15th International conference on Persuasive Technology* (2020).

[125] Oyebode, O. and Orji, R. 2020. (PDF) A Persuasive Mobile Game for Reducing Sedentary Behaviour and Promoting Physical Activity. *Persuasive 2020, Adjunct proceedings of the 15th International conference on Persuasive Technology.* (2020).

[126] P., W.S. and "Tico," B.R. 2007. Pervasive Persuasive: A Rhetorical Design Approach to a Location-Based Spell-Casting Game for Tourists. (2007).

[127] Peng, W. 2009. Design and evaluation of a computer game to promote a healthy diet for young adults. *Health Communication*. 24, 2 (Mar. 2009), 115–127. DOI:https://doi.org/10.1080/10410230802676490.

[128] Pentz, M.A. et al. 2019. A videogame intervention for tobacco product use prevention in adolescents. *Addictive Behaviors*. 91, (Apr. 2019), 188–192. DOI:https://doi.org/10.1016/j.addbeh.2018.11.016.

[129] Perrotta, C. et al. 2013. *Game-Based Learning: Latest Evidence and Future Directions*. National Foundation for Educational Research.

[130] Pollak, J.P. et al. 2010. It's time to Eat! Using mobile games to promote healthy eating. *IEEE Pervasive Computing*. 9, 3 (Jul. 2010), 21–27. DOI:https://doi.org/10.1109/MPRV.2010.41.

[131] Pollak, J.P. et al. 2010. It's time to Eat! Using mobile games to promote healthy eating. *IEEE Pervasive Computing*. 9, 3 (2010), 21–27.

DOI:https://doi.org/10.1109/MPRV.2010.41.

[132] Preist, C. et al. 2014. Competing or aiming to be average? Normification as a means of engaging digital volunteers. *Proceedings of the ACM Conference on Computer Supported Cooperative Work, CSCW*. (2014), 1222–1233. DOI:https://doi.org/10.1145/2531602.2531615.

[133] Prochaska, J.O. et al. 1992. In search of how people change: Applications to addictive behaviors. *American Psychologist*. 47, 9 (1992), 1102–1114. DOI:https://doi.org/10.1037//0003-066x.47.9.1102.

[134] Prochaska, J.O. 2013. Transtheoretical Model of Behavior Change. *Encyclopedia of Behavioral Medicine*. M.D. Gellman and J.R. Turner, eds. Springer New York. 1997–2000.

[135] Reeves, B. et al. 2012. Leveraging the engagement of games to change energy behavior. *Proceedings of the 2012 International Conference on Collaboration Technologies and Systems, CTS 2012* (2012), 354–358.

[136] Ren, X. et al. 2020. Weaving Healthy Behaviors into New Technology Routines: Designing in (and for) the COVID-19 Work-from-Home Period. (2020). DOI:https://doi.org/10.1145/3393914.3395911.

[137] Ruggiero, D. *The Effect of a Persuasive Game on Attitude Towards the Homeless*.

[138] Sangeeta, M. 2014. EFFECTIVENESS OF ARCS MODEL OF MOTIVATIONAL DESIGN TO OVERCOME NON COMPLETION RATE OF STUDENTS IN DISTANCE EDUCATION. *Turkish Online Journal of Distance Education*. 15, (2014), 7.

[139] Schall, V.T. et al. 1999. Evaluation of the ZIG-ZAIDS game: an entertaining educational tool for HIV/Aids prevention. *Cadernos de Saúde Pública*. 15, suppl 2 (1999), S107–S119. DOI:https://doi.org/10.1590/s0102-311x1999000600011.

[140] Schnall, R. et al. 2015. mHealth Technology as a Persuasive Tool for Treatment, Care and Management of Persons Living with HIV. *AIDS and Behavior*. 19, 2 (Jun. 2015), 81–89. DOI:https://doi.org/10.1007/s10461-014-0984-8.

[141] Shih, C.H. et al. 2011. Assisting people with multiple disabilities by actively keeping the head in an upright position with a Nintendo Wii Remote Controller through the control of an environmental stimulation. *Research in Developmental Disabilities*. 32, 5 (Sep. 2011), 2005–2010. DOI:https://doi.org/10.1016/j.ridd.2011.04.008.

[142] Shrestha, N. et al. 2020. The impact of COVID-19 on globalization. *One Health*. 11, (Dec. 2020), 100180. DOI:https://doi.org/10.1016/j.onehlt.2020.100180.

[143] Simon, J. et al. 2012. Saving energy at work: The design of a pervasive game for office spaces. *Proceedings of the 11th International Conference on Mobile and Ubiquitous Multimedia, MUM 2012* (New York, New York, USA, 2012), 1.

[144] Small, R. V. 1997. *ED409895 1997-00-00 Motivation in Instructional Design. ERIC Digest*. ERIC Clearinghouse on Information and Technology, 4-194 Center for Science and Technology, Syracuse, NY 13244-4100 (free while supplies lasts).

[145] Soler, C. et al. 2009. Molarcropolis: A mobile persuasive game to raise oral health and dental hygiene awareness. *ACM International Conference Proceeding Series* (New York, New York, USA, 2009), 388–391.

[146] Stockdale, J. et al. 2014. *Applying the ARCS design model to breastfeeding advice by midwives in order to motivate mothers to personalise their experience*. Royal College of Midwives.

[147] Tandon, P. 2020. COVID-19: Impact on health of people & wealth of nations. *Indian Journal of Medical Research*. Wolters Kluwer Medknow Publications.

[148] Thomas, R.J. et al. 2019. Can I Influence You? Development of a Scale to Measure Perceived Persuasiveness and Two Studies Showing the Use of the Scale. *Frontiers in Artificial Intelligence*. 2, (Nov. 2019), 24. DOI:https://doi.org/10.3389/frai.2019.00024.

[149] Tian, H. et al. 2020. An investigation of transmission control measures during the first 50 days of the COVID-19 epidemic in China. *Science*. 368, 6491 (Mar. 2020), eabb6105. DOI:https://doi.org/10.1126/science.abb6105.

[150] Toscos, T. et al. 2006. Chick Clique: Persuasive technology to motivate teenage girls to exercise. *Conference on Human Factors in Computing Systems - Proceedings*. (2006), 1873–1878. DOI:https://doi.org/10.1145/1125451.1125805.

[151] Ufrj, S. et al. *Stop Disasters Game Experiment with Elementary School Students in Rio de Janeiro: Building Safety Culture*.

[152] Unity: *https://unity.com/solutions/game*.

[153] Wais-Zechmann, B. et al. 2018. Persuasive technology to support chronic health conditions: Investigating the optimal persuasive strategies for persons with COPD. *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial*

Intelligence and Lecture Notes in Bioinformatics) (Apr. 2018), 255–266.

[154] Wein, A. and Labiosa, W. Serious Games Experiment toward Agent-based Simulation.

[155] WHO Coronavirus Disease (COVID-19) Dashboard: .

[156] Williams, O. et al. 2014. Effect of a novel video game on stroke knowledge of 9- To lo-year-old, low-income children. *Stroke*. 45, 3 (2014), 889–892. DOI:https://doi.org/10.1161/STROKEAHA.113.002906.

[157] Winskell, K. et al. 2018. A smartphone game-based intervention (Tumaini) to prevent HIV among young africans: Pilot randomized controlled trial. *JMIR mHealth and uHealth*. 6, 8 (Aug. 2018). DOI:https://doi.org/10.2196/10482.

[158] World Health Organization (WHO): 2021. *https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public*.

[159] Wu, F. et al. 2020. A new coronavirus associated with human respiratory disease in China. *Nature*. 579, 7798 (Mar. 2020), 265–269. DOI:https://doi.org/10.1038/s41586-020-2008-3.

[160] Ying, M.H. and Yang, K.T. 2013. A game-based learning system using the ARCS model and fuzzy logic. *Journal of Software*. 8, 9 (2013), 2155–2162. DOI:https://doi.org/10.4304/jsw.8.9.2155-2162.

[161] Yoon, S.L. and Godwin, A. 2007. Enhancing self-management in children with sickle cell disease through playing a CD-ROM educational game: a pilot study. *Pediatric nursing*. 33, 1 (Jan. 2007), 60–63, 72.

[162] Yusoff, Z. and Kamsin, A. 2015. Game rhetoric: Interaction design model of persuasive learning for serious games. *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)* (2015), 644–654.

[163] Zulkifli, A.N. et al. 2015. Interactive persuasive learning elements among elderly: A measurement model. *Jurnal Teknologi*. 77, 4 (Nov. 2015), 145–153. DOI:https://doi.org/10.11113/jt.v77.6055.

[164] Intrinsic Motivation Inventory (IMI) – selfdeterminationtheory.org. DOI:https://doi.org/https://selfdeterminationtheory.org/intrinsic-motivation-inventory/.

APPENDIX A. List of My Publications

1. **Dinesh Mulchandani** and Rita Orji. 2021. A Persuasive Game to Promote Awareness and Adoption of COVID-19 Precautionary Measures; In proceedings of UMAP '21: 29th Conference on User Modelling, Adaption and Personalization, June 21-25, 2021. ACM, Utrecht, Netherlands. 5 pages.
2. **Dinesh Mulchandani** and Rita Orji. 2021. Persuasiveness of a Game to Promote the Adoption of COVID-19 Precautionary Measures and the Moderating Effect of Gender; ADAPPT (Adaptive and Personalized Persuasive Technology) 2021; In proceedings of UMAP '21: 29th Conference on User Modelling, Adaption and Personalization, June 21-25, 2021. ACM, Utrecht, Netherlands. 14 pages.
3. Oladapo Oyebode, Chinenye Ndulue, **Dinesh Mulchandani**, Ashfaq A. Zamil Adib, Mona Alhasani, and Rita Orji. 2021. Tailoring Persuasive and Behaviour Change Systems Based on Stages of Change and Motivation. In Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems. Association for Computing Machinery, New York, NY, USA, Article 703, 1–19. DOI: https://doi.org/10.1145/3411764.3445619
4. Oyebode O, Ndulue C, Adib A, **Mulchandani D**, Suruliraj B, Orji FA, Chambers CT, Meier S, Orji R. Health, Psychosocial, and Social Issues Emanating From the COVID-19 Pandemic Based on Social Media Comments: Text Mining and Thematic Analysis Approach. JMIR Med Inform. 2021 Apr 6;9(4):e22734. doi: 10.2196/22734. PMID: 33684052; PMCID: PMC8025920.
5. Mona Alhasani, **Dinesh Mulchandani**, Oladapo Oyebode, and Rita Orji. 2020. *A Systematic Review of Persuasive Strategies in Stress Management Apps*. Behaviour Chage Support Systems, 2020. http://ceur-ws.org/Vol-2662/BCSS2020_paper4.pdf
6. Godfrey D., Findlay C., **Mulchandani D**., Subramanilyer R., Conrad C., Newman A. (2020) A Tri-Hybrid Brain-Computer Interface for Neuro-Information Systems. In: Davis F.D., Riedl R., vom Brocke J., Léger PM., Randolph A.B., Fischer T. (eds) Information Systems and Neuroscience. NeuroIS 2020. Lecture Notes in Information Systems and Organisation, vol 43. Springer, Cham. https://doi.org/10.1007/978-3-030-60073-0_34

APPENDIX B. Permission to Use

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APPENDIX C. Pre-Test Survey Questions

Section 1: Demographics (email (optional for lucky draw), age group, gender, education, country of residence, gaming frequency, and preferred gaming platform)

Section 2: TTM Questions

Select the One option that best applies to you.

Precontemplation	I don't take any precautionary measures against COVID, such as using hand sanitizers, face masks, hand gloves; and I have not thought about starting any of these activities
Contemplation	I don't take any precautionary measures against COVID (such as using hand sanitizers, face masks, hand gloves), but I do think about starting it in the near future
Preparation	I am planning to take all precautionary measures against COVID - such as using hand sanitizers, face masks, hand gloves, but can't do it regularly
Action	In the last 6 months, I started practicing all the precautionary measures in my routine to avoid COVID
Maintenance	More than 6 months ago, I started practicing all the precautionary measures in my routine to avoid COVID
Termination	I am always following the COVID-19 precaution and safety guideline. It is part of my daily life.

Section 3: COVID Knowledge Test

Please, respond the following questions to the best of your knowledge. Please, do not use the internet to search for the answer.

How is COVID-19 passed on?	Through droplets that come from your mouth and nose when you cough or breathe out (A) In sexual fluids, including semen, vaginal fluids or anal mucous By drinking unclean water All of the above
What are the common symptoms of COVID-19?	A new and continuous cough

	Fever Tiredness All of the above (A)
Can washing your hands protect you from COVID-19?	Yes – but only if you use a strong bleach Yes – normal soap and water or hand sanitizer is enough (A) No – Washing your hands doesn't stop COVID-19
Which of the following people is COVID-19 more dangerous for?	Children Older people Young Adults General Population (A)
When should face masks be worn to stay protected from COVID-19?	On public transport In confined or crowded spaces In small shops All of the above (A)
Which of the following is an example of physical distancing?	You stop going to crowded places and visiting other people's houses (A) You stop talking to the people you live with You stop speaking to your friends on the phone
How can people protect themselves from COVID-19?	Wash their hands regularly and follow the physical distancing advice Wear face masks at public places Exercise regularly, eat well and look after their mental health All of the above (A)
How long can the virus live outside the body?	

	24 hours 48 hours 72 hours (A) 96 hours

Section 4: Attitude, Intention, and Self Efficacy

Attitude

I believe wearing face masks to protect against COVID-19 is:
Unimportant 1 2 3 4 5 6 7 Important
Useless 1 2 3 4 5 6 7 Useful
Worthless 1 2 3 4 5 6 7 Valuable
Ineffective1 2 3 4 5 6 7 Effective
Harmful 1 2 3 4 5 6 7 Beneficial
Unnecessary 1 2 3 4 5 6 7 Necessary
Bad 1 2 3 4 5 6 7 Good

I believe sanitizing or washing my hands frequently to protect against COVID-19 is:
Unimportant 1 2 3 4 5 6 7 Important
Useless 1 2 3 4 5 6 7 Useful
Worthless 1 2 3 4 5 6 7 Valuable
Ineffective1 2 3 4 5 6 7 Effective
Harmful 1 2 3 4 5 6 7 Beneficial
Unnecessary 1 2 3 4 5 6 7 Necessary
Bad 1 2 3 4 5 6 7 Good

I believe staying 6-feet apart from other people to protect against COVID-19 is:
Unimportant 1 2 3 4 5 6 7 Important
Useless 1 2 3 4 5 6 7 Useful
Worthless 1 2 3 4 5 6 7 Valuable
Ineffective1 2 3 4 5 6 7 Effective
Harmful 1 2 3 4 5 6 7 Beneficial
Unnecessary 1 2 3 4 5 6 7 Necessary
Bad 1 2 3 4 5 6 7 Good

Intention

I intend to always wear face masks in public to avoid the spread of COVID-19.	1-Extremely unlikely	7- Extremely likely
I intend to always stay 6-feet apart from other people in the public to avoid the spread of COVID-19.	1-Extremely unlikely	7- Extremely likely
I intend to always wash my hands with soap and water to avoid the spread of COVID-19	1-Extremely unlikely	7- Extremely likely
I intend to always sanitize my hand and any item I collect from public places (like malls and stores)	1-Extremely unlikely	7- Extremely likely
I intend to try to avoid public spaces that can cause contact with people leading to the spread of COVID-19	1-Extremely unlikely	7- Extremely likely

Self-Efficacy

I am confident that I can always wear a face mask in public.	1-strongly disagree	7- strongly agree
I am confident that I can always sanitize and wash my hands.	1-strongly disagree	7- strongly agree
I am confident that I can always maintain a 6-feet distance from other people.	1-strongly disagree	7- strongly agree
I am confident that I would always insist on wearing a face mask in public even if other people do not wear it.	1-strongly disagree	7- strongly agree
I am confident that I would always insist on sanitizing and washing my hands even if other people do not.	1-strongly disagree	7- strongly agree
I am confident that I would always insist on maintaining a 6-feet distance from other people even if other people do not.	1-strongly disagree	7- strongly agree

APPENDIX D. Post-Test Survey Questions

Section 1: Email (optional for entering lucky draw)

Section 2: COVID Knowledge Test

Please, respond the following questions to the best of your knowledge. Please, do not use the internet to search for the answer.

How is COVID-19 passed on?	Through droplets that come from your mouth and nose when you cough or breathe out (A) In sexual fluids, including semen, vaginal fluids or anal mucous By drinking unclean water All of the above
What are the common symptoms of COVID-19?	A new and continuous cough Fever Tiredness All of the above (A)
Can washing your hands protect you from COVID-19?	Yes – but only if you use a strong bleach Yes – normal soap and water or hand sanitizer is enough (A) No – Washing your hands doesn't stop COVID-19
Which of the following people is COVID-19 more dangerous for?	Children Older people Young Adults General Population (A)
When should face masks be worn to stay protected from COVID-19?	On public transport In confined or crowded spaces

	In small shops All of the above (A)
Which of the following is an example of physical distancing?	You stop going to crowded places and visiting other people's houses (A) You stop talking to the people you live with You stop speaking to your friends on the phone
How can people protect themselves from COVID-19?	Wash their hands regularly and follow the physical distancing advice Wear face masks at public places Exercise regularly, eat well and look after their mental health All of the above (A)
How long can the virus live outside the body?	24 hours 48 hours 72 hours (A) 96 hours

Section 3: Attitude, Intention, and Self Efficacy

Attitude

I believe wearing face masks to protect against COVID-19 is:
Unimportant 1 2 3 4 5 6 7 Important
Useless 1 2 3 4 5 6 7 Useful
Worthless 1 2 3 4 5 6 7 Valuable
Ineffective1 2 3 4 5 6 7 Effective
Harmful 1 2 3 4 5 6 7 Beneficial
Unnecessary 1 2 3 4 5 6 7 Necessary
Bad 1 2 3 4 5 6 7 Good

I believe sanitizing or washing my hands frequently to protect against COVID-19 is:
Unimportant 1 2 3 4 5 6 7 Important
Useless 1 2 3 4 5 6 7 Useful

Worthless 1 2 3 4 5 6 7 Valuable
Ineffective1 2 3 4 5 6 7 Effective
Harmful 1 2 3 4 5 6 7 Beneficial
Unnecessary 1 2 3 4 5 6 7 Necessary
Bad 1 2 3 4 5 6 7 Good

I believe staying 6-feet apart from other people to protect against COVID-19 is:
Unimportant 1 2 3 4 5 6 7 Important
Useless 1 2 3 4 5 6 7 Useful
Worthless 1 2 3 4 5 6 7 Valuable
Ineffective1 2 3 4 5 6 7 Effective
Harmful 1 2 3 4 5 6 7 Beneficial
Unnecessary 1 2 3 4 5 6 7 Necessary
Bad 1 2 3 4 5 6 7 Good

Please provide comments to justify your ratings above:

Intention

I intend to always wear face masks in public to avoid the spread of COVID-19.	1-Extremely unlikely	7- Extremely likely
I intend to always stay 6-feet apart from other people in the public to avoid the spread of COVID-19.	1-Extremely unlikely	7- Extremely likely
I intend to always wash my hands with soap and water to avoid the spread of COVID-19	1-Extremely unlikely	7- Extremely likely
I intend to always sanitize my hand and any item I collect from public places (like malls and stores)	1-Extremely unlikely	7- Extremely likely
I intend to try to avoid public spaces that can cause contact with people leading to the spread of COVID-19	1-Extremely unlikely	7- Extremely likely

Please provide comments to justify your ratings above**:**

Self-Efficacy

I am confident that I can always wear a face mask in public.	1-strongly disagree	7- strongly agree

I am confident that I can always sanitize and wash my hands.	1-strongly disagree	7- strongly agree
I am confident that I can always maintain a 6-feet distance from other people.	1-strongly disagree	7- strongly agree
I am confident that I would always insist on wearing a face mask in public even if other people do not wear it.	1-strongly disagree	7- strongly agree
I am confident that I would always insist on sanitizing and washing my hands even if other people do not.	1-strongly disagree	7- strongly agree
I am confident that I would always insist on maintaining a 6-feet distance from other people even if other people do not.	1-strongly disagree	7- strongly agree

Please provide comments to justify your ratings above**:**

Section 4: Persuasiveness Scale

Questions	**1-Strongly Disagree**						**7- Strongly Agree**
This game influenced me to adopt COVID-19 precautionary measures.	1	2	3	4	5	6	7
This game convinced me to adopt COVID-19 precautionary measures.	1	2	3	4	5	6	7
This game is personally relevant to me.	1	2	3	4	5	6	7
This game made me reconsider my current behaviour towards adopting the COVID-19 precautionary measures.	1	2	3	4	5	6	7
This game would motivate me to follow COVID-19 precautionary measures.	1	2	3	4	5	6	7

Section 5: ARCS

Attention	**1-Strongly Disagree**						**7- Strongly Agree**
The game captured and held my attention.	1	2	3	4	5	6	7
The game has some contents that stimulates my curiosity.	1	2	3	4	5	6	7
Relevance							
The content of the game is relevant to me.	1	2	3	4	5	6	7
I can relate with the content of this game.	1	2	3	4	5	6	7
The content of the game makes sense to me.	1	2	3	4	5	6	7
The content of the game is useful to me.	1	2	3	4	5	6	7
Confidence							
It is easy to understand and use the game.	1	2	3	4	5	6	7
The game helped me to improve my awareness towards adoption of COVID precautionary	1	2	3	4	5	6	7

measures (e.g., using hand sanitizer, face mask, tissues, and hand gloves).	
The game helped build my confidence in my ability to improve my behaviour regarding the adoption of COVID precautionary measures.	1 2 3 4 5 6 7
Satisfaction	
I really enjoyed playing the game.	1 2 3 4 5 6 7
It would be a pleasure to play a game like this.	1 2 3 4 5 6 7
The game helped me accomplish my behaviour goal.	1 2 3 4 5 6 7

Section 6: IMI

Interest / Enjoyment	**1-Strongly Disagree**						**7- Strongly Agree**
I enjoyed playing this game very much.	1	2	3	4	5	6	7
Playing this game was fun.	1	2	3	4	5	6	7
I would describe playing this game as very interesting.	1	2	3	4	5	6	7
Playing this game was quite enjoyable.	1	2	3	4	5	6	7
Playing this game was boring activity. (R)	1	2	3	4	5	6	7
Value / Usefulness	1	2	3	4	5	6	7
I believe playing this game is of value to me.	1	2	3	4	5	6	7
I think that playing this game is useful for improving the awareness in the adoption of COVID-19 precautionary measures.	1	2	3	4	5	6	7
I think playing this game is important because it can improve my current behaviour and knowledge to avoid COVID-19	1	2	3	4	5	6	7
I believe playing this game could be beneficial to me.	1	2	3	4	5	6	7
I would be willing to play this game again because it has some value to me.	1	2	3	4	5	6	7
Effort / Importance							
I put a lot of effort into playing this game.	1	2	3	4	5	6	7
I tried very hard on playing this game.	1	2	3	4	5	6	7
It was important to me to do well at this game.	1	2	3	4	5	6	7
I didn't put much energy into playing this game. (R)	1	2	3	4	5	6	7
Perceived Tension							
I did not feel nervous at all while playing this game. (R)	1	2	3	4	5	6	7
I felt very tense while playing this game.	1	2	3	4	5	6	7
I was very relaxed in playing this game. (R)	1	2	3	4	5	6	7
I was anxious while playing this game.	1	2	3	4	5	6	7
I felt pressured while playing this game.	1	2	3	4	5	6	7
Perceived Competence							
I think I am pretty good at playing this game.	1	2	3	4	5	6	7
After playing this game for a while, I felt pretty competent.	1	2	3	4	5	6	7
I am satisfied with my performance at this game.	1	2	3	4	5	6	7
I was pretty skilled at this game.	1	2	3	4	5	6	7
This was a game that I couldn't play very well. (R)	1	2	3	4	5	6	7

APPENDIX E. Interview Questions

1. Tell us what do like / dislike about the COVID Pacman?
2. What did you learn about COVID from playing the game?
3. Did the game raise your awareness about covid-19? How?
4. Did the game make you reflect on Covid19 and how?
5. How did game rewards impact how you played the game? (only for players who player version one)
6. How did suggestions for COVID-19 precautionary measures impact how you played the game? (only for players who player version one)
7. How did health bar monitoring impact how you played the game? (only for players who player version two)
8. How did leaderboard of competition impact how you played the game? (only for players who player version two)
9. What do you like about the game in general?
10. What don't you like about the game?
11. Any suggestions for improvement in COVID Pacman?
12. What did you learn from the game in general?

APPENDIX F. Research Ethics Board Approval Letter

Social Sciences & Humanities Research Ethics Board
Letter of Approval

November 30, 2020
Dinesh Mulchandani
Computer Science\Computer Science

Dear Dinesh,

REB #: 2020-5342
Project Title: COVID Pacman: A Persuasive Game for Behaviour Change in the Adaption of COVD-19 Precautionary Measures

Effective Date: November 30, 2020
Expiry Date: November 30, 2021
The Social Sciences & Humanities Research Ethics Board has reviewed your application for research involving humans and found the proposed research to be in accordance with the Tri-Council Policy Statement on *Ethical Conduct for Research Involving Humans.* This approval will be in effect for 12 months as indicated above. This approval is subject to the conditions listed below which constitute your on-going responsibilities with respect to the ethical conduct of this research.

Effective March 16, 2020: Notwithstanding this approval, any research conducted during the COVID-19 public health emergency must comply with federal and provincial public health advice as well as directives from Dalhousie University (and/or other facilities or jurisdictions where the research will occur) regarding preventing the spread of COVID-19.
Sincerely,

Dr. Karen Foster, Chair
